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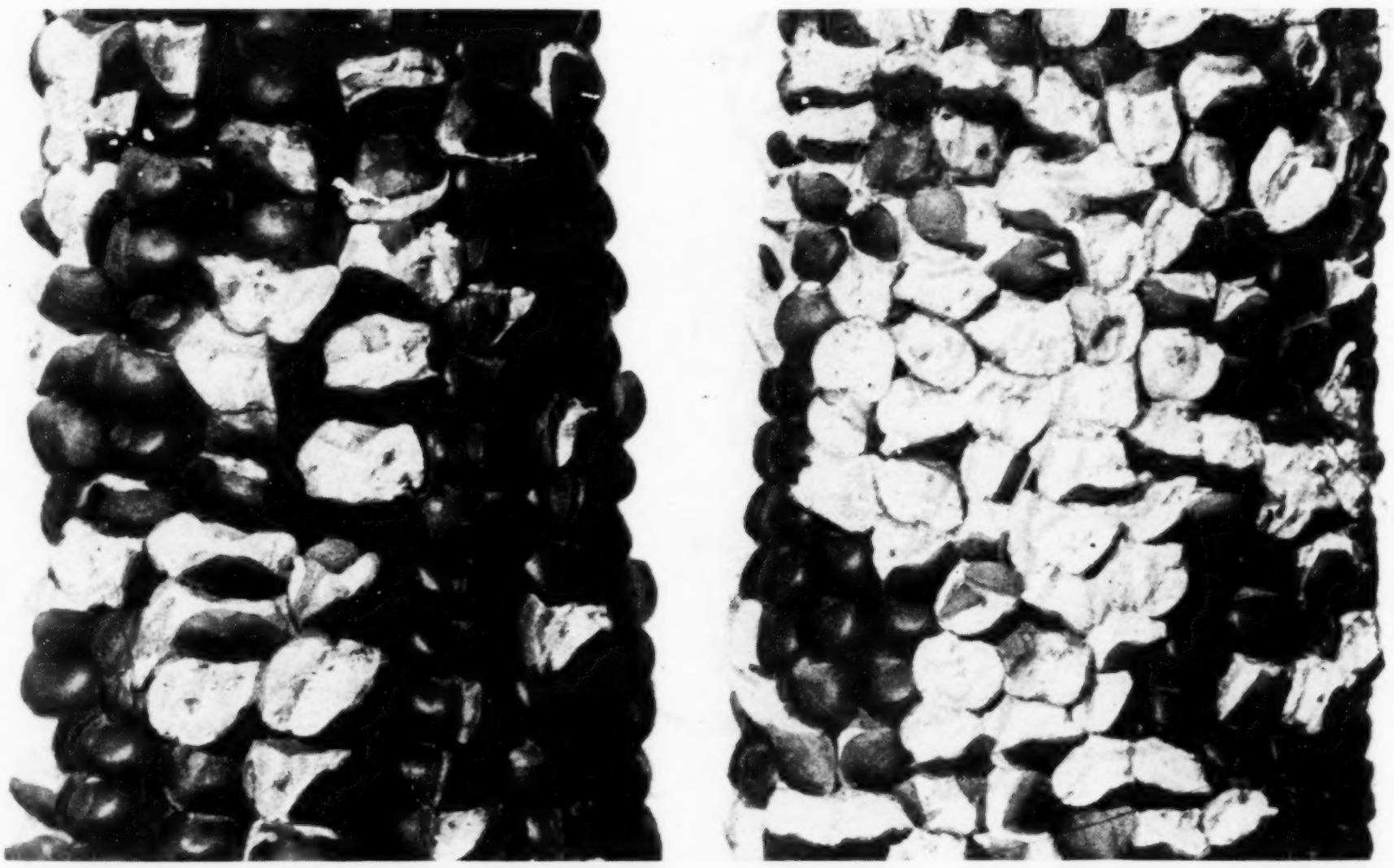

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A Handbook of Human Heredity
A Review

JULY, 1925 VOL. 16 No. 7

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The

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Corrugated

Golden Buckeye

TWO KINDS OF ORANGES FROM A SINGLE TREE

Frontispiece

These fruits, representing the Corrugated and Golden Buckeye limb variations, were both taken from the tree shown in Figure 1. In outward appearance and in the character of the skin and pulp they differ widely from the fruits produced on the normal part of the tree, and the differences are perpetuated in buds taken from these limbs. Photographed at Victoria Ranch, January, 1915.

BUD SELECTION IN THE WASHINGTON NAVEL ORANGE

Progeny Tests of the Thomson, Washington, Corrugated, and Golden Buckeye Strains Originating as Limb Variations on a Single Tree

A. D. Shamel, C. S. Pomeroy and R. E. Caryl
Bureau Plant Industry, United States Department of Agriculture

DESCRIPTIONS of a number of bud variations of the Washington Navel orange and a discussion of their relation to the origin and development of important strains of this variety have been presented in an earlier publication.[1] Evidence has also been published showing that variations in the quantity[2] and quality[3] of Washington Navel orange fruits may occur as bud variations and that such variations may be perpetuated through bud propagation. Further striking variations of fruit quality originating as limb variations in a tree of the Thomson strain of the Washington Navel orange are described herein.

The Thomson Strain Parent Tree

Orchards of the Thomson strain of the Washington Navel orange were planted rather extensively in the Southwest during the period from about 1900 to 1910. On coming into bearing many trees in these orchards were found to produce such frequent and diverse fruit variations as to seriously reduce the value of their crops. In the orchards where individual-tree performance record studies were carried on, these variations were found as individual fruits, as limbs bearing several fruits and as entire trees. The difficulty in assorting these crops into uniform standard grades and the losses resulting from the elimination of the inferior and worthless fruit variations were contributory reasons which checked the further propagation of this strain, and its commercial propagation has been discontinued in recent years.

A typically variable tree composed largely of branches representative of the normal Thomson strain with three striking limb variations was found in 1910 (see Figure 1), by the senior writer in a full bearing commercial orchard of this strain at Riverside, California, on the Victoria ranch of the National Orange Company. In addition to normal fruits of the Thomson strain, shown in Figure 3, typical oranges of the Washington, Corrugated and Golden Buckeye strains (see Figure 3 and the Frontispiece) were produced by other limbs of this tree which was grown from a single bud propagated on Mission Sweet Seedling rootstock and planted in the orchard in 1901. Subsequent observations on the fruiting of this tree showed that the different limbs produced their characteristic fruits consistently every year.

The trees of the Thomson strain are productive, have an open and somewhat drooping habit of growth, dense foliage and dark-green leaves.

The fruits are similar in shape and size to those of the Washington strain but are more attractive on account of having a very smooth rind of a bright reddish orange color. The more abundant and coarser rag and the somewhat inferior quality of the juice of the

PARENT THOMSON TREE, WITH THREE LIMB VARIATIONS

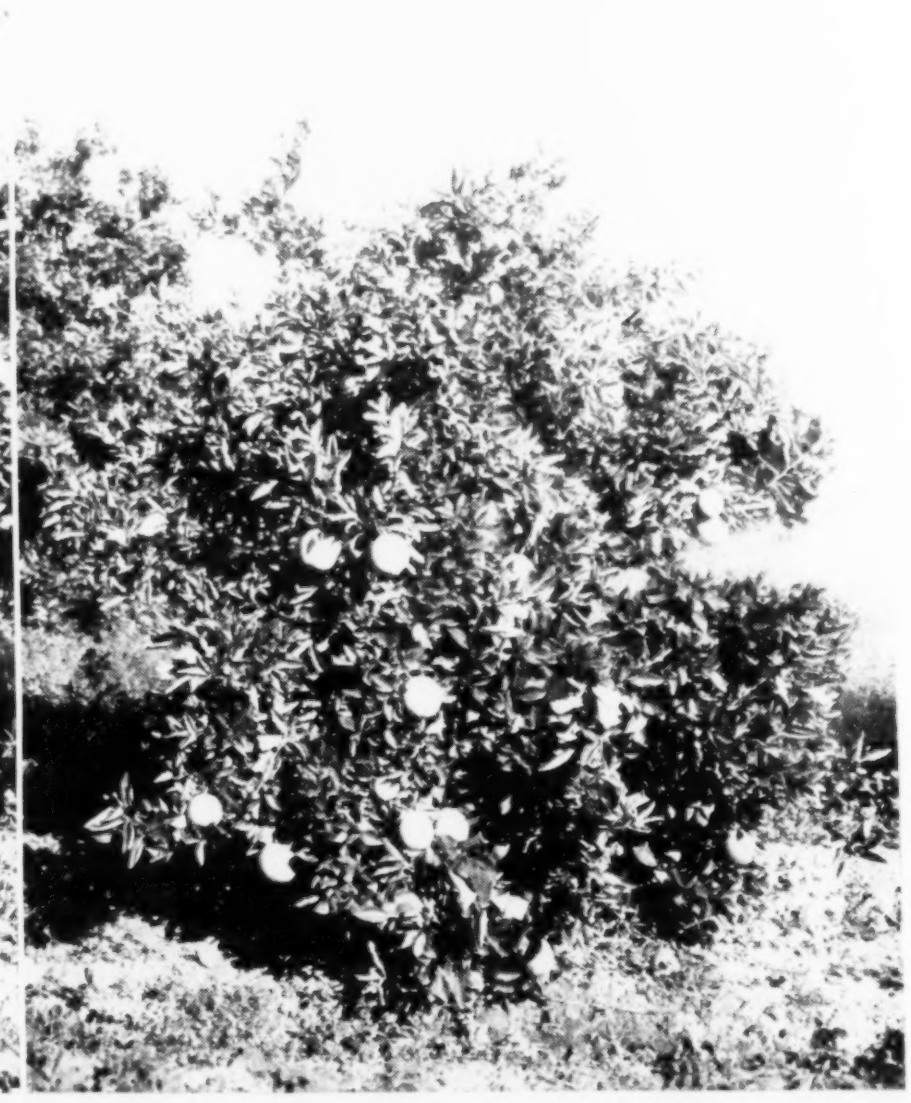
Figure 1

This tree of the Thomson strain of the Washington Navel orange has limb variations of the Washington, Corrugated, and Golden Buckeye strains. All four of these strains were propagated, and each of the progeny trees bore fruit characteristic of the parent limb from which the bud was taken. Photographed at the Victoria Ranch, National Orange Company, Riverside, California, January, 1923.

Thomson

Washington

Corrugated



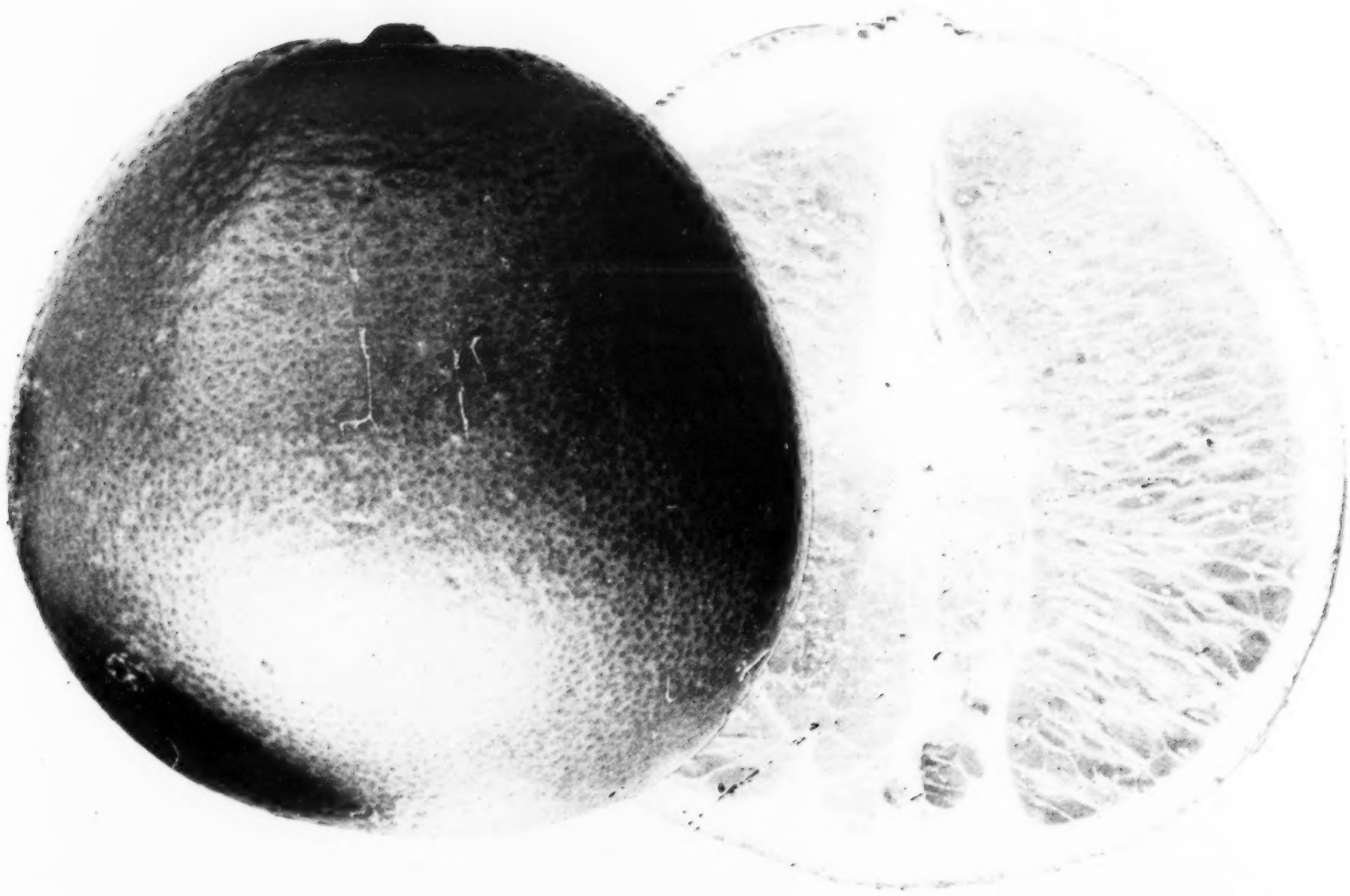
Golden Buckeye

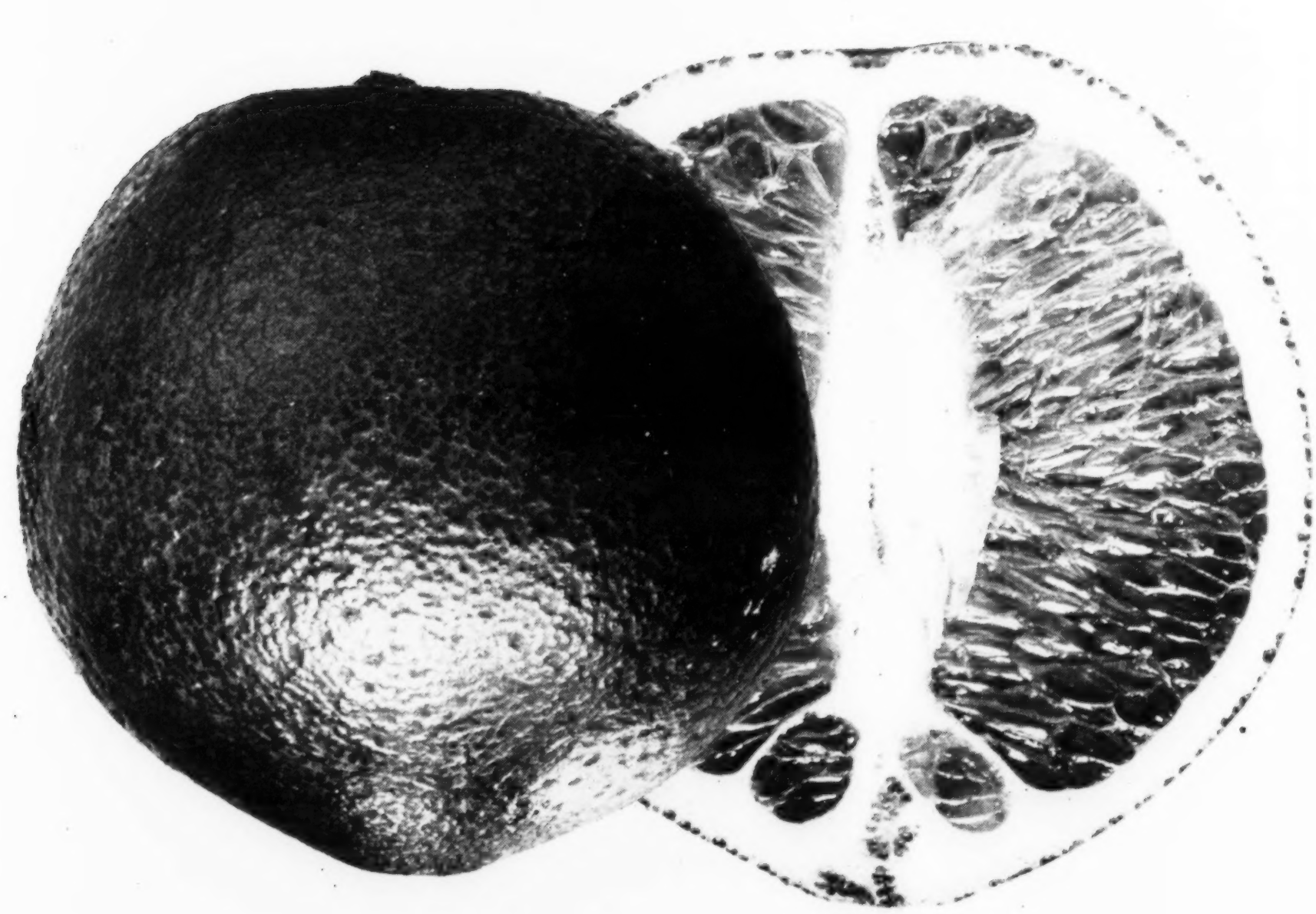
PROGENY TREES FROM PARENT THOMSON TREE

Figure 2

These four trees were propagated from different limbs of the Thomson tree shown in Figure 1. Each of the trees produces fruit characteristic of the limb from which it was taken. Typical fruits from these trees are shown in Figures 4 and 5. Photographed at University of California Citrus Experiment Station, Riverside, California, January 5, 1923.

Thomson





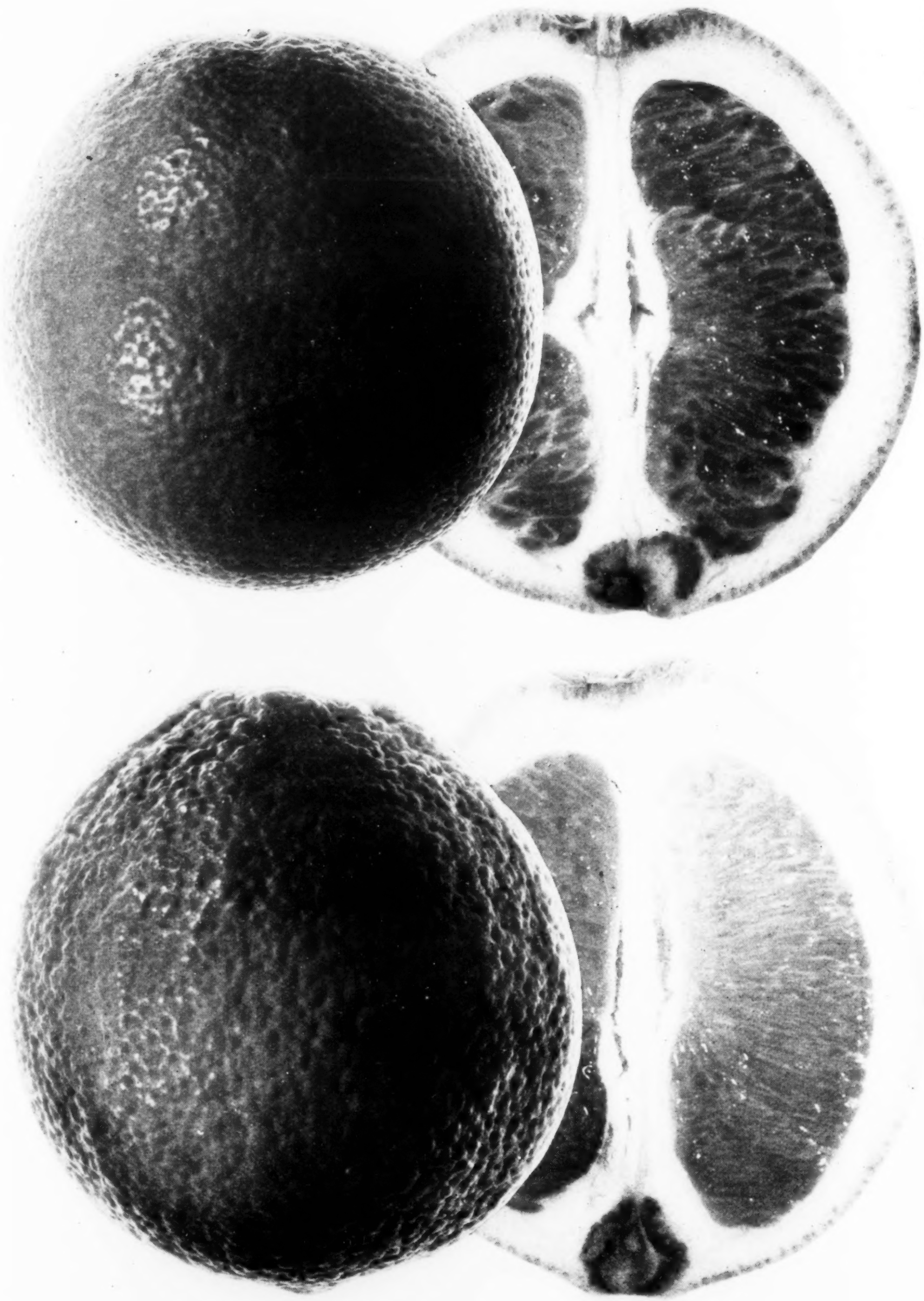
Washington

THOMSON AND WASHINGTON FRUITS FROM PARENT TREE

Figure 3

Above is shown typical fruit of the Thomson strain of the Washington Navel orange, borne on the normal part of the tree shown in Figure 1. Below is fruit typical of the Washington strain, borne on a limb variation of the same tree. Limb variations of the Corrugated and Golden Buckeye strains were also found on this tree (See Frontispiece). Photographed at Victoria Ranch, January, 1915.

Thomson



Washington

THOMSON AND WASHINGTON FRUITS FROM PROGENY TREES

Figure 4

Typical fruit produced by two of the trees shown in Figure 2, which were propagated from different limbs of the same tree (see Figure 1). Note the similarity between these fruits and those from the parent limbs, shown in Figure 3. Photographed at Citrus Experiment Station, January 5, 1923.

Thomson fruits are undesirable characteristics which reduce their market value. The fruits are seedless and the navel is of medium to small size.

The Washington Strain Limb Variation

One of the large branches of the parent tree bears a number of typical fruits of the Washington strain (see Figure 3), and others of the Corrugated strain. This condition is believed to show a reverting variation to the original type (Washington strain) of the variety and the appearance of another variation, the Corrugated form.

The fruit of the Washington strain is obovoid in shape and of medium to large size. The rind is of medium thickness, usually somewhat thicker than the rind of fruits of the Thomson strain and the texture is evenly grained. The color of the fruit is bright orange; the rag is tender and comparatively small in amount; the juice is abundant and of superior quality, having a pleasing and sprightly sub-acid flavor. The fruits are seedless and the navel is usually small, frequently rudimentary with no development except in the rind. The Washington fruits are easily distinguished from those of the Thomson strain by the characteristic differences in color and texture of the rind, the amount and coarseness of the rag and the amount and flavor of the juice.

As stated above, one of the large branches of the parent Thomson tree bears fruits typical of both the original Washington strain and of the sporting Corrugated strain. This latter strain usually occurs as a relatively unstable variation and limb sports of this strain as well as progeny trees propagated from them frequently show varying proportions of abnormal and normal fruits from year to year. In this instance this branch was bearing at the time propagations were made from it in January, 1915, thirty-five Corrugated fruits and twenty-one of the Washington strain.

The Corrugated Strain Limb Variation

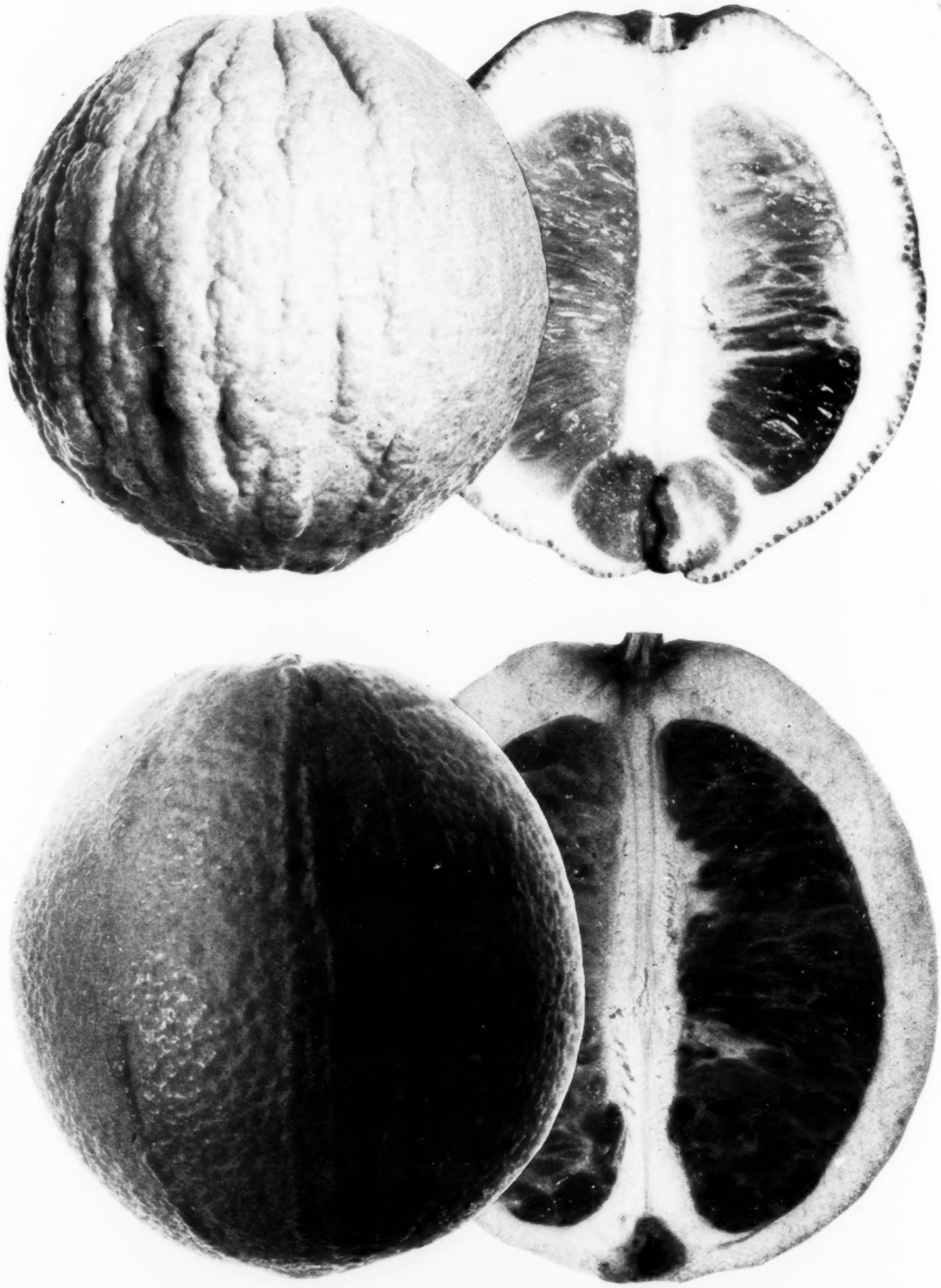
The fruits of the Corrugated strain are very different from those of other Washington Navel orange strains, being very ridged or corrugated, as shown in the Frontispiece. They are globose in shape and of medium to large size. The rind is of medium thickness and the color yellowish orange. The rag is tender and small in quantity and the juice is fairly abundant and of fair quality. The fruits are seedless and the navels small to medium in size. On account of the striking and prominent ridging and markings the fruits of this strain are easily distinguished from those of other Washington Navel orange strains. The rather frequent occurrence of these fruits as bud variations in trees of other strains renders their study of unusual interest from the viewpoint of bud selection in the commercial propagation of the Washington Navel variety.

The Golden Buckeye Strain Limb Variation

Another limb of the Thomson strain parent tree bears fruits of the Golden Buckeye strain, as shown in the Frontispiece. The fruits of this strain are similar in appearance to those of the Golden Nugget strain but have more ridges or raised sections.

The Golden Buckeye oranges usually are somewhat elliptical or pyriform in shape and of medium to large size. The rind is thin and of light yellowish-orange color and the characteristic ridges are irregular in shape and size and reddish-orange in color. The rag is coarse and very abundant, the juice is somewhat deficient in quantity and frequently of distinctive quality. The fruits are seedless and normally have only very small navels. The navel openings are often very small or entirely closed. The fruits have a peculiar appearance, due in part to the presence of comparatively few oil cells, the light yellowish-orange

Corrugated



Golden Buckeye

CORRUGATED AND GOLDEN BUCKEYE FRUITS FROM PROGENY TREES

Figure 5

These fruits are from two of the progeny trees shown in Figure 2. Each of the progeny trees bore fruit typical of the limb variations from which the buds were taken. It is evident from these experiments that inferior or actually undesirable types of fruit may be perpetuated by careless selection of budwood. Photographed at Citrus Experiment Station, January 5, 1923.

color of the rinds and the prominent reddish ridges, raised sections or knoblike projections. They are easily identified and distinguished from the fruits of other Washington Navel orange strains.

Progeny Propagation

On January 19, 1915, buds were secured from a normal Thomson strain limb, a Washington strain branch, the Corrugated strain branch and the Golden Buckeye limb of the Thomson strain parent tree and propagated on sour orange seedlings in a commercial nursery in cooperation with the Citrus Experiment Station of the University of California. The resulting progeny trees were transplanted July 2, 1917, to the progeny orchard in the variety block at the Citrus Experiment Station of the University of California at Riverside, California. These progenies consist of two trees propagated from the Corrugated branch variation, two trees propagated from the Washington branch variation, two trees propagated from the Golden Buckeye branch variation, and one tree propagated from the normal Thomson portion of the parent tree. Illustrations of trees of each of these progenies are shown in Figure 2.

The trees were planted ten feet apart in the order named under comparatively uniform environmental conditions. They have been given good cultural care continuously. Winter and summer legume cover crops have been grown in the orchard each year and plowed under and the trees have made a vigorous and healthy growth beginning production in the season of 1920-21.

Progeny Performance Records

The crops from each progeny tree have been picked annually since the trees came into bearing, the fruits being segregated according to their strain characteristics and their number recorded. The performance records of these trees are shown in Table I.

These data indicate that the differences in fruit characteristics which were first observed on the different limbs of the parent Thomson tree were of an inherent nature due to somatic bud variation and that they have been transmitted through asexual propagation to the progenies of these individual limb variations.

The single progeny tree of the normal Thomson limb has produced a total of 542 fruits all of which were typical of this strain and similar to those borne by the parent limb, as shown in Figure 4.

The two progeny trees of the Washington limb have produced 613 and 678 fruits respectively for the period of five seasons, 1920-21, to 1924-25 inclusive. All of these fruits have been typical of the Washington strain and similar in all respects to those borne by the parent limb, as shown in Figure 4.

Of the two progeny trees of the Corrugated limb one has produced 257 Corrugated and 142 Washington fruits, while the other has borne 645 Corrugated and 45 Washington fruits during the five-year period. The presence of fruits of both the Corrugated and Washington strains on these trees shows the ever-sporting or unstable character of the Corrugated strain as was the case with the parent limb variation. Fruits borne by one of the Corrugated progeny trees are illustrated in Figure 5.

The two progeny trees of the Golden Buckeye limb have produced 484 and 557 fruits respectively. All of these fruits are typical of the Golden Buckeye strain and similar to those borne by the parent limb, as shown in Figure 5.

Conclusion

The results of these progeny tests indicate that the characteristics of the Thomson strain, Washington strain, Corrugated strain, and Golden Buckeye strain have been transmitted from the limb variations to the progeny trees.

These studies suggest the probability that trees of diverse strains in established citrus orchards may be due to the unintentional propagation of similar limb variations in normal nursery operations.

These progeny tests emphasize the fundamental importance of careful bud selection in the commercial propagation of citrus trees in order that the production of the individual trees in orchard plantings may be improved and made more uniformly like that of the best trees of each variety.

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TABLE I.—Records of the number of fruits produced annually by progeny trees propagated from limb variations bearing fruit of the Washington, Corrugated and Golden Buckeye strains in a single parent tree and from th enormal portion of the same tree which is of the Thomson strain of the Washington Navel orange and was grown from a single bud.

Strain	*Tree No.*	1920-21	1921-22	1922-23	1923-24	1924-25	*Totals*
Progeny of Normal Thomson Limb	1	18 T[1]	76 T	73 T	247 T	148 T	562 T
Progeny of Washington Limb	2	15 W[2]	95 W	98 W	277 W	128 W	613 W
	3	25 W	140 W	104 W	253 W	156 W	678 W
Progeny of Corrugated Limb	4	1 C[3] 2 W	11 C 14 W	83 C 16 W	133 C 87 W	29 C 23 W	257 C 142 W
	5	1 C	21 C	117 C 2 W	345 C 61 W	161 C 2 W	645 C 45 W
Progeny of Golden Buckeye Limb	6	20 GB[4]	114 GB	60 GB	216 GB	74 GB	484 GB
	7	25 GB	101 GB	59 GB	259 GB	113 GB	557 GB

[1]T indicates fruit of the Thomson strain. [2]W indicates fruit of the Washington strain. [3]C indicates fruit of the Corrugated strain. [4]GB indicates fruit of the Golden Buckeye strain.

Third Edition of "Genetics and Eugenics"

GENETICS AND EUGENICS. A text-book for Students of Biology and a Reference Book for Animal and Plant Breeders, by Dr. W. E. CASTLE, Professor of Zoology in Harvard University and Research Associate of the Carnegie Institution of Washington, 434 pages. Harvard University Press, Cambridge, Mass., 1924.

The appearance of the third edition of Professor Castle's book is an indicator of the success which it has met as a text-book of genetics. The present edition shows extensive revision. A wholly new Part I on the "Biological Basis of Genetics," has been added. In six brief chapters the author gives a review of the cell theory and especially of the behavior of the chromosomes. Two other new chapters deal briefly but in a well balanced way with the application of genetics to plant and animal breeding. Another new chapter sums up the author's view on the "Relation of mendelism to mutation and evolution." He emphasizes that while the recent period of discovery in genetics has its origin to a large extent in de Vries' theory of discontinuous evolution by "Mutations," the progress of genetic discovery has practically carried us back to Darwin's views on the gradual nature of variation and the guiding influence of selection. Besides the addition of these chapters, a comparison with the preceding edition shows numerous minor additions and changes in the text which serve to clarify statements and bring the subject matter to date.

Prof. Castle's book is not an encyclopedic compilation of facts; neither is it a dogmatic presentation of principles in the traditional text book style. It stands out as a thoroughly readable book in which the more significant experimental data in the field are presented in a well digested form. The fact that every chapter shows evidence of the author's own thought on the subject discussed and on its broader implications makes it of great interest to those who are familiar with the subject matter as well as to those to whom it serves as a first approach. *S. W.*

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PHYSICAL GROWTH OF TWO GENERATIONS OF ONE FAMILY

BIRD T. BALDWIN AND MADORA E. SMITH
Iowa Child Welfare Research Station, State University of Iowa

THE FAMILY OF EIGHT CHILDREN
Figure 6

From left to right, top row: No. 1, No. 3, No. 2; middle row. John, No. 7, No. 4, No. 8, and Fanny; bottom row: No. 5 and No. 6. The family lived in China until the youngest child was two years old. In spite of the unfavorable conditions Fanny and John were able to raise their family with very few serious illnesses, and at the same time they kept a remarkably complete record of the growth of the children.

ABOUT thirty-six years ago, a young mother interested in the development of her first baby began to keep record of her children's progress in the form of a journal. Her primary purposes were to keep the records for comparison, for her own information, and to present the record to the child on his eighteenth birthday. The children's journals were more complete than the usual Baby Book. They were kept over a period of almost twenty years from the birth of the eldest child in January, 1886, until the eighteenth birthday of the second child in July, 1905. From 1886 to 1900 the family were in China, during which period the records were carefully kept in detail. From 1900 to 1905, they are less detailed, having been recorded

*The writers are indebted to Mrs. F. M. Smith and to Mrs. C. L. Foster for assistance in securing the original data.

somewhat irregularly. In each journal is recorded the child's weight, taken usually at monthly intervals from the child's birth; the height, measured once or twice a year from birth, supplemented by notes as to illness, progress in lessons, general development, events of importance to the child, and observations in regard to his character and training.

Not only the mother kept this record but the two daughters who have married kept similar ones for their own children. Two of the three daughters-in-law have also recorded some data about their children which have been supplemented by more data collected by an aunt, one of the authors of this report. There are eleven grandchildren from over eight months to nine years of age. The data vary from some scattered records concerning one boy to the careful, frequent records kept by the eldest daughter of her five children.

Parentage

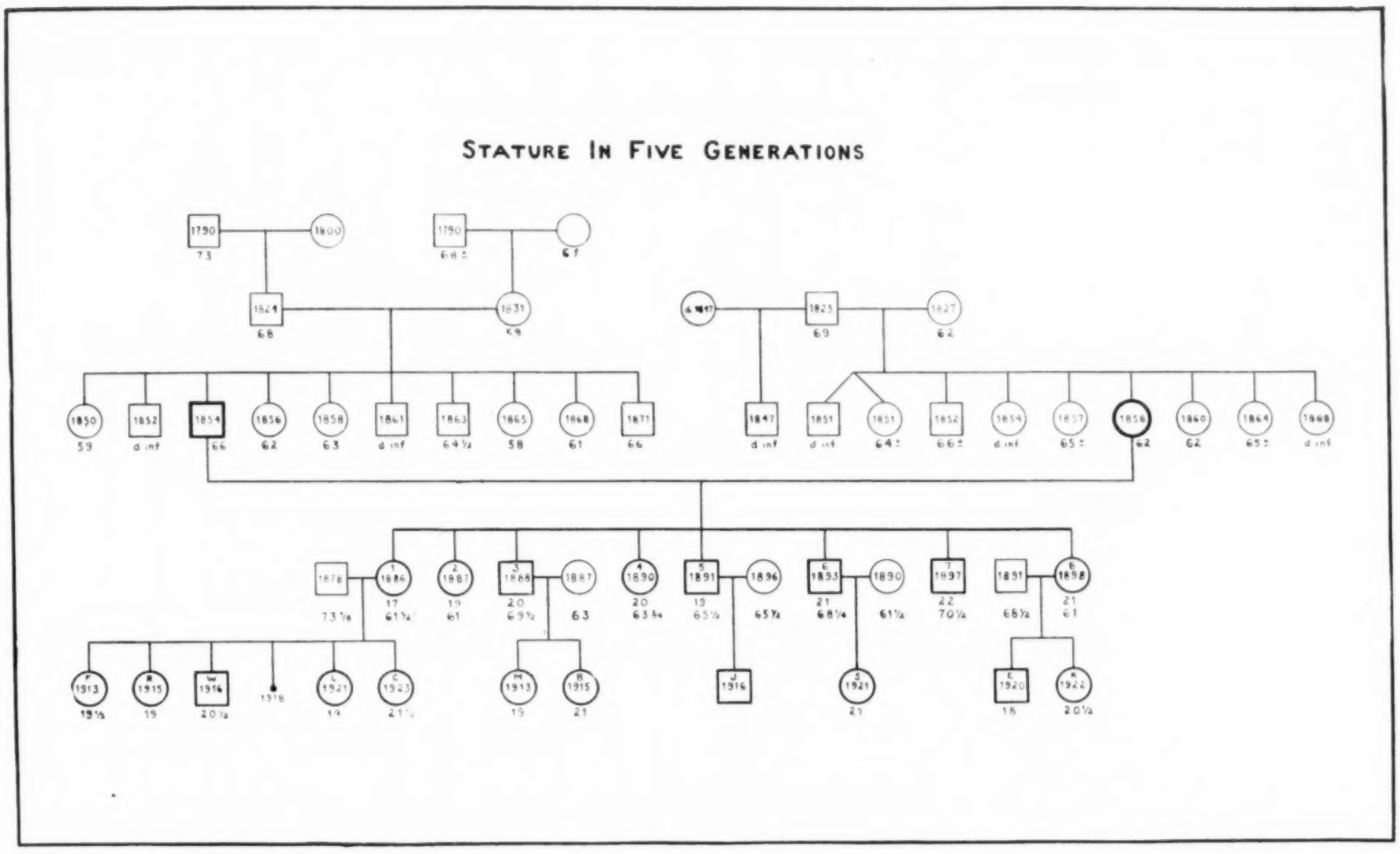
The father, John, was born June 4, 1854, on a farm near Moro, Illinois. His father was of Scotch-Irish descent, and was born in Pennsylvania, as were both his parents. His mother was of French, Welsh and Scotch descent and was born in Ohio. Her father was born in the Isle of Jersey and was a sailor. Soon after John's birth his parents moved to the small town of Moro, where John's father became a prosperous country merchant. John graduated from college in 1875 and from theological seminary in 1879. Years afterward his classmates remembered him as an unusually able student.

In personal appearance, John was five feet six inches tall and weighed about 150 pounds. His sitting-height was tall relatively to his standing height, perhaps due to his French heredity. This peculiarity is found in three of his daughters and one son. He had brown hair and gray eyes as had all his four sons. His eyes were crossed from infancy due, according to his mother, to a fall from the bed when he was a few months old. This defect was not corrected until after his marriage. From 1881 to 1900, he lived in China. During that time he was engaged in pastoral, educational, or literary work. He did some translation into Chinese and wrote frequently for his church papers. His avocations were reading and carpentry, at which he was quite skillful.

The mother, Fanny, was born in Monroe, Michigan, November 14, 1858. Her father, a Presbyterian minister, and the eldest of three sons, was born in New York State, and was of English descent. Fanny's mother was the fourth of five daughters and her husband's second wife. They were married less than two years after the death of his first wife and her little son. Fanny was her mother's sixth child.

Physically, Fanny had much to contend with. Infantile paralysis when quite young left her slightly lame and left-handed, owing to the fact that her right side did not grow for some time. An operation for cataract was necessary at fourteen years, and an attack of spinal meningitis following a fall confined her to her bed for five months when she was seventeen years old. After nineteen years of age, she enjoyed good health and was vigorous and energetic. Before the birth of the youngest child she became very much run down, suffering with many boils, and soon after was seriousiy ill with sprue. Since then attacks of rheumatism and trouble with varicose veins have been practically her only ailments. At sixty-three she is still engaged in active work as a city missionary and is in fair health. At marriage Fanny was five feet, two inches tall and weighed about 120 pounds. She has brown eyes, as have all of her daughters, and brown hair which turned quite white in her thirties. Her second and third children in the early thirties already had not a little white hair.

At school, Fanny always stood high in her classes. She taught school for



STATURE IN FIVE GENERATIONS

Figure 7

Height at birth and adult height (in inches) is given for the eight children, and the height at birth of the grandchildren. The similar stature of parents and children at birth is apparent in the last two generations.

a term in America and two years in China, where she went as a missionary in 1882.

March 14, 1885, John and Fanny were married. After marriage, Fanny did some translation into Chinese, considerable visiting in the Chinese homes and other missionary work, and, with the exception of two autumn school terms, educated her children until their departure from China.

John and Fanny had eight children (Figures 6 and 8):

No. 1, girl, born January	23, 1886
No. 2, girl, born July	2, 1887
No. 3, boy, born November	12, 1888
No. 4, girl, born June	14, 1890
No. 5, boy, born November	27, 1891
No. 6, boy, born November	3, 1893
No. 7, boy, born February	15, 1897
No. 8, girl, born July	26, 1898

Early Environment of the Children

John and Fanny made their home in Shanghai, China, until 1894, with the exception of the year July, 1890, to August, 1891, spent on furlough in the United States. In 1894, the family moved to Ningpo, about 130 miles to the south, where, with the exception of six months in 1897, they lived until March, 1900, when they left China to live in the United States. After a few months spent in visiting relatives in Colorado and in Tennessee, and a year in Illinois, they settled in North Dakota, where they lived until they moved to Iowa in 1905. The six older children were all born in Shanghai; the two youngest in Ningpo, China.

Shanghai and Ningpo are at latitudes 31 and 30, respectively, approximately that of New Orleans. Both are within twelve miles of the sea coast. The climate is damp with long hot summers and winters chilly rather than cold. Very little snow is seen. At Shanghai, the average humidity is 80, yearly rainfall 43.6 and mean temperature 58.8*. Shanghai, even then, had

*Data from Chinese Year Book.

quite a modern European settlement, but the family lived in the native city.

Peculiar hygienic difficulties surround a family in a Chinese city. Fresh milk was hard to obtain. It and the drinking water had to be boiled. Meat of animals dying a natural death was sold in the markets. Raw fruits and vegetables were unsafe to eat owing to the method of fertilization. The streets were dirty and sewage was not carefully disposed of. There was no quarantine of contagious diseases. The climate of the cities where the family lived added to the unhealthy conditions. The summers, which are much damper than the winters, are very oppressive and malaria is prevalent. All these facts result in a high death rate for both Chinese and foreign children.

Yet Fanny and John were able to raise all of their eight children, and with very few serious illnesses, although all had most of the usual children's diseases and all but one had to undergo tonsilectomy. Particular care was taken as to regularity of sleeping and eating and exposure to the sun during the hot summer. Two summers, 1888 and 1896, were spent in Japan and four, 1887, 1894, 1895, and 1899, at the hills near Ningpo. Every child was vaccinated within a few months after birth, and again at six years, and also whenever exposed to smallpox, which was often. The children were permitted to play with but few Chinese children without supervision and their foreign playmates were few, though cosmopolitan, so they depended mainly upon each other for companionship.

Physical Growth of Eight Children

1. Weight

The custom of the family was to weigh each baby at birth and thereafter (except for the two eldest who were weighed monthly) at weekly or semi-monthly intervals, until one or two years old, on the weekly or monthly anniversary of his birth. After his second birthday, the baby was weighed with the whole group of children in the evening between supper and bedtime every month, about the first or last of the month. The child was weighed either nude or else as soon as weighed, his clothing was removed and weighed separately and the net weight recorded. When traveling in the United States in 1890-91, this was not possible and the weights for that year include clothing. In the accompanying tables such weights are given in brackets.

2. Height

Height was measured at birth, at one year, and after that usually on some child's birthday or New Year's day. The average number of separate height measures per child is twenty-one. The heights were measured without shoes. As soon as the baby could stand, he was placed against a doorpost and the father, using his carpenter's square and measure, carefully marked the height on the post and measured the distance. In referring to the different children the custom observed by their Chinese servants and friends of calling them No. 1, No. 2, and so forth, will be followed.

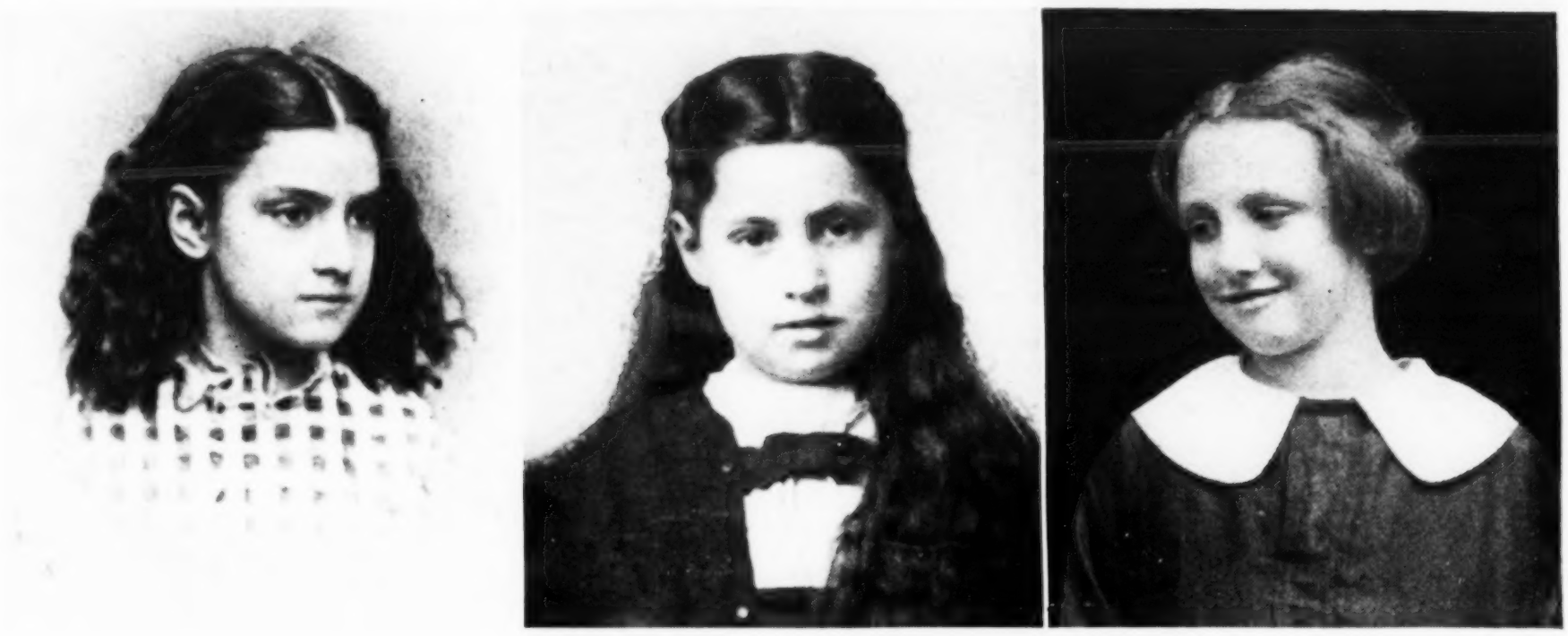
3.—Seasonal Variation in Growth of Weight and Height

Fanny's children, when taken together or grouped as babies under two years and above six months, as girls and as boys, all show the same variations in gain in weight. From September through January the gain is most rapid, October being the month of greatest gain in weight. In February there is a marked drop. From March through April there is a moderate gain, and from May through August there are slight gains or losses, especially in June.

In height the period of greatest growth is from May to November, especially in July and August.

4. Dentition

The record is quite complete for first dentition, but very few data were preserved regarding second dentition.



THREE GENERATIONS

Figure 8

From left to right, Fanny, No. 8, and No. 3's elder daughter (M), all at about ten years.

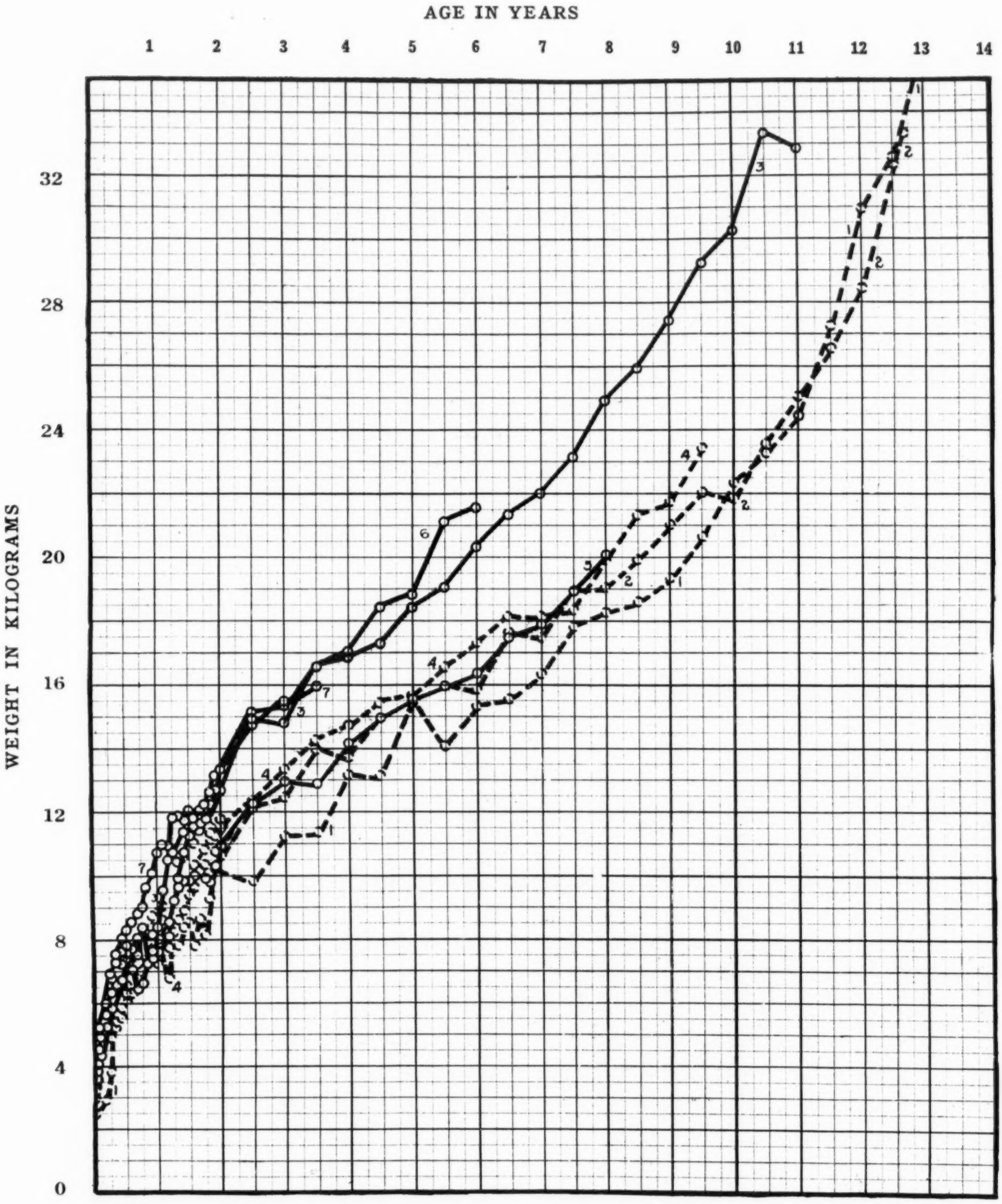
The curves show that the children beginning dentition early also finished early and those beginning late also finished late. Thus, No. 3 and No. 6, who cut their first teeth at six and seven months, respectively, cut the twentieth at twenty-four months. No. 4, No. 5, and No. 7, who began at eight, eight, and nine months, respectively, finished at twenty-eight months. No. 1 and No. 8, who began at eleven and thirteen months, respectively, did not finish until thirty-two and thirty-four months old. Number 8's slowness may have been due to rickets; but her son did not cut his first tooth until thirteen months old either. Number 2 is the exception. She cut her first tooth at six months and, according to rule, should have finished about the same age as 3 and 6 but did not until twenty-nine months old. Just why is not very clear. However, she had measles and whooping cough during this time and was quite sick with some digestive disorder at about one year and with fever at two years. During the interval from fifteen to twenty-one months that she cut no teeth she was treated by the doctor for bow legs. She cut her teeth hard. Perhaps she was rickety. Number 6's curve falls back during the time he was ill with malarial scurvy, but he recovered his rank when he was well. He always possessed unusual recuperative powers after illness.

5. *Apparent Influence of Sex and Order of Birth*

In height we find a steady increase of birth height for the girls according to order of birth, seventeen, nineteen, twenty, twenty-one inches, and the same increase for boys except for No. 5, who is shorter than his predecessor, No. 3. In weight the girls follow the same rule of increase of size according to order of birth except that No. 8, who was born when her mother was not well, is three ounces lighter than her next elder sister. Each boy is heavier than the last.

The boys were longer and heavier than the girls at birth and the shortest man is taller than the tallest woman. The four younger children were longer and heavier than the four elder at birth, this difference being greater than that between the sexes. As three of the boys belong in the younger group and only one is in the elder it is only by comparing the individuals separately that we see that both sex and order of birth apparently have a share in determining the difference.

In cutting teeth, the boys were in advance of the girls as to time of eruption of both first and last tooth, and



INDIVIDUAL GROWTH CURVES IN WEIGHT OF THE EIGHT CHILDREN

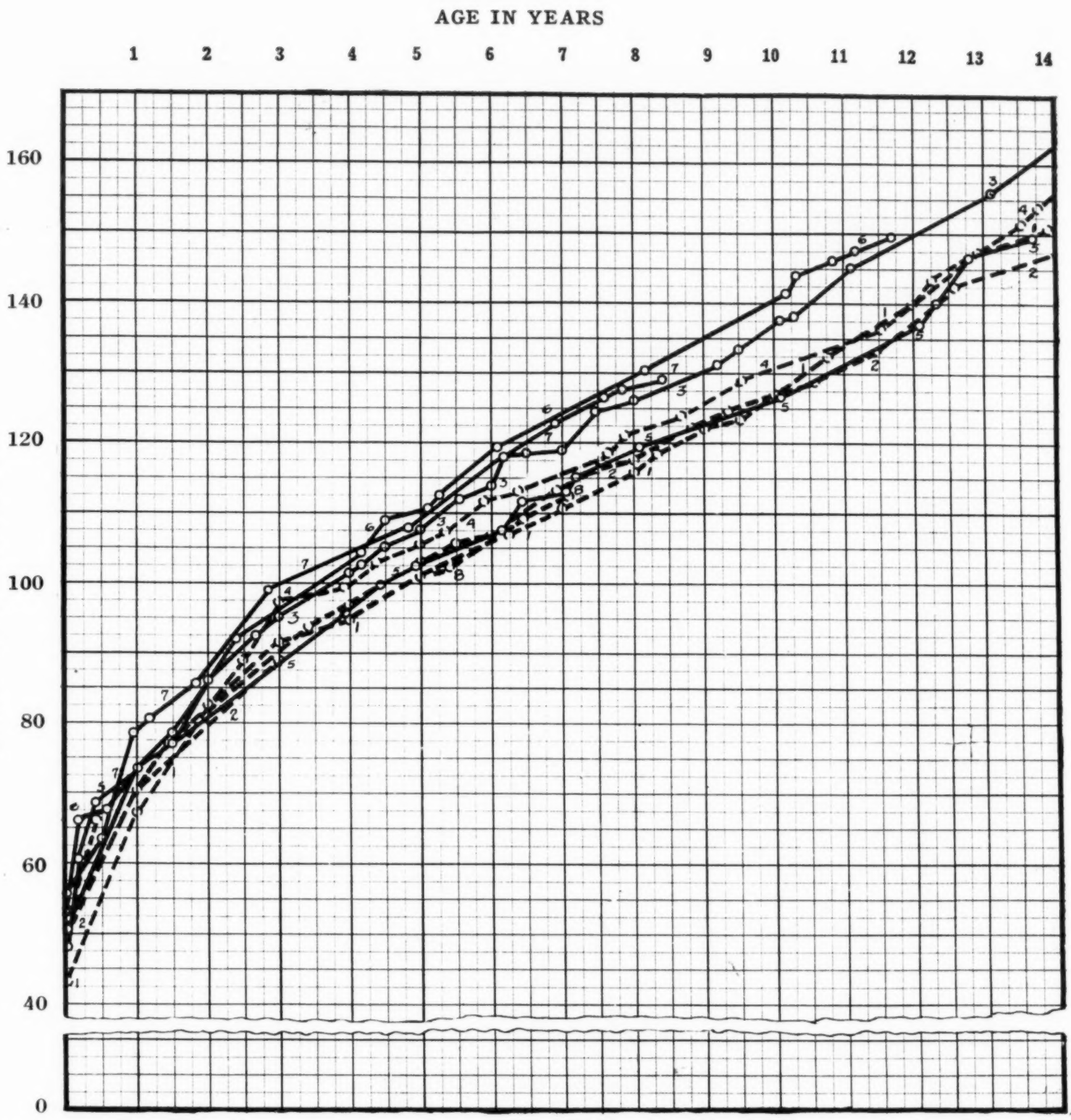
Figure 9

The curves of the sisters are more variable than those of normal healthy girls under favorable living conditions. The life of the family in China no doubt adversely affected the weight of the children. (Boys, ——; girls, — — — —.)

the four older preceded the four younger ones in cutting the first tooth, but tied in cutting the last. In talking and walking it is the younger ones who are first, owing, doubtless, in part to the example of their older brothers and sisters. The girls walked first and the boys talked first, but very little earlier.

6. Comparative Ranking at Different Ages

The girls hold the same order of height at six years and when adult,

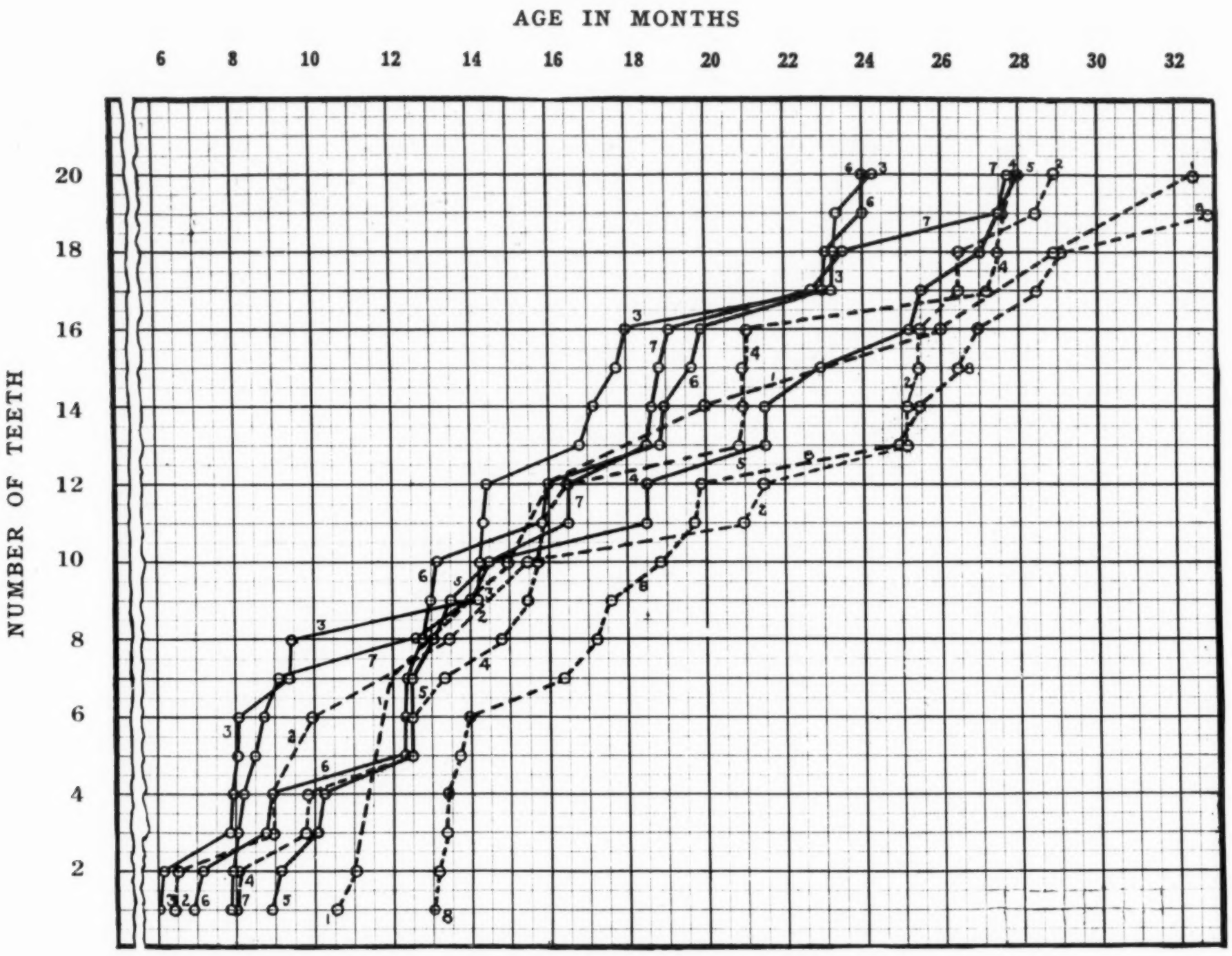


INDIVIDUAL GROWTH CURVES IN HEIGHT OF FOUR BROTHERS AND FOUR SISTERS

Figure 10

These curves are noticeably uniform, in general trend. The boys are taller than the girls. No. 5 was the shortest boy at birth. He maintains this comparative rank in stature among his brothers in all later records. (Boys, ——; girls, — — — —.)

except that No. 8, who was the longest at birth, falls back almost as low as No. 2. Comparisons of their heights at three and a half years show that the change in rank took place before then. Possible causes may be found in the conditions of No. 8's birth and infancy. She was born not long before the furlough of her overtired parents was due. About a year previous to her birth her father had been refused life insurance on account of suspicion of Bright's disease. Her mother was in comparatively poor health, in much poorer condition than previous to the birth of the other seven. At the time of No. 8's birth, Fanny was a rival of Job in the number of boils—at one time 160 were counted on her body. When No. 8 was two months old, Fanny was attacked by sprue, an oriental disease very difficult to cure. She was ill for some time and had to wean No. 8 earlier than any other of her children. When No. 8 was weaned at three and



DENTITION OF FOUR BROTHERS AND FOUR SISTERS

Figure 11

In this family two of the girls had a tendency to late dentition, which was apparent in their children also. (Boys, ——; girls, — — — —.)

a half months she had fever, and during her first year suffered several times from indigestion and cried a good deal even when apparently well. At seven and a half months, she had whooping-cough. Although the youngest of all the children to talk and walk, she was abnormally slow at teething, cut her first tooth the day after she was thirteen months old and the 20th at thirty-four months. During her first summer, ten to twelve months, she was very fretful and had an abscess on her head. At fifteen months, she had a fever for three weeks. At twenty months, the family started on their journey to America. During the journey, she kept fairly well, but her appetite was capricious and easily upset. Then at twenty-six months she had measles. At four and a half years she had pneumonia and was very ill. Like all her sisters she had enlarged tonsils, which with adenoids were not removed until she was thirteen, a later age than that at which her sisters underwent the operation. Her sisters have a better disease history. Before four years old, No. 1 had diarrhoea in her second summer, measles at three years, and whooping cough six months later. No. 2 had measles at twenty-one months, whooping cough at two years and occasionally fever or a cold. No. 4 had cholera infantum at fifteen months and no other serious illness. It would appear that the physical condition of her parents at birth and her own illnesses, among them possibly rickets, during the first two years of her life stunted No. 8's growth.

No. 2 always exceeded No. 1 in height, except between eleven and fourteen years; at eighteen years No. 1's height was one inch less. Her tem-

porary superiority in this trait was no doubt due to her adolescent acceleration with early maturity, since she matured two years younger than No. 2.

The failure of No. 6 to keep the same relative rank is more difficult to explain. Some time after he was eleven years old, he gave his place to No. 3, now the next tallest of the brothers. Comparison of the disease history of the two shows No. 6 had many more severe illnesses than No. 3.

No. 6 was also troubled with indigestion from two and a half to three years of age. Both had tonsilitis frequently, but whereas clipping No. 3's tonsils at eight and a half years cured his trouble, No. 6 had his removed at seven, nine and a half, and at twenty-eight years. Evidently his trouble was never properly corrected. It is possible that these diseases checked his growth. Comparison of his weight and height curves with those of his daughter also indicate that his growth was checked during his illness in his first and second years. Another cause, perhaps, was the change in climate. No. 6 was brought to America early, as the family moved to North Dakota when he was six and a half years old, while No. 3 was eleven years. Boas found that Italian children moved to the United States from a warmer climate when quite young were shorter than those born in the United States or those born in Italy and remaining there. When we compare the percentage of norms in height of the children of our family at birth and as adults, we find that the younger children brought to the United States from a warmer climate at an early age attain a lower percentage of the adult norm in comparison to the birth norm than the older children.

The Eleven Grandchildren of Fanny and John

The children discussed in Part I are grown and Numbers 1, 3, 5, 6, and 8, have married and have families of their own. Numbers 1, 8, and the wife of 6 are keeping records more or less complete of their children and we have also some scattered data concerning the children of 3 and 5.

1. Family of No. 1

No. 1, F, born January 23, 1886

No. 1, after teaching three years in America, returned to China as a missionary in 1910, where she was married, April 18, 1912, to C. F., a Baptist missionary. Her family of four girls and one boy is growing up in China at the same latitude but further inland than she did.

C. F. is a professor, was a Phi Beta Kappa at college, and holds the degrees of B. A. and M. A. He was born February 5, 1878, in New York State. Most of his relatives were farmers. He is now six feet, one and five-eighths inches tall, and weighs about 176 pounds. He has blue eyes and light brown hair. His mother died during his boyhood and his two sisters died in their teens of tuberculosis. His father died in 1910.

In studying the records of No. 1's children, we find a tendency for the younger children to learn more rapidly to talk than the elder with the exception that the boy, third in order of birth, is slower than the second child. The same tendency for those cutting teeth earlier to finish earlier noted in Fanny's children is seen here. All are slow in teething, however, not finishing until over two and a half years old, as did their mother. The taller of the two eldest girls has cut her teeth, both temporary and permanent, earlier than did the shorter girl, but the shorter girl was quicker at learning to walk, and talk, and is reported to be quicker at school work, except for music, than the taller girl. The three older children have had tonsils and adenoids removed, as have both their parents. They seem rather subject to respiratory diseases.

In height and weight the girls are holding their relative position. The boy does not. His curves of height and

weight follow more closely his mother's and he looks more like her than do his sisters. All are taller than their mother at the same age. So were they at birth, and their father is tall.

No. 1's children do not show quite the same seasonal variations that Fanny's children showed. They grow in height most rapidly from May through November, the most rapid growth being, however, in May and June, October and November. This excludes their growth during the first year.

No. 1's children are not affected by the hot summer so much as Fanny's. That is probably due to the fact that they have spent two of the total nine summers in the United States and the others all at the hills, and for longer times than Fanny's children did. Note the improvement in July, the earliest month Fanny's family ever left for the hills. October's phenomenal gains may be due to reaction from the loss felt during the summer. The children of No. 1 usually left the latter part of June for their vacation.

Family of No. 3

No. 3, M, born November 12, 1888

No. 3 went into engineering work after graduation from college, but left that and entered business after his marriage, which took place December twenty-eighth, 1912. His wife, C, was born September third, 1887, in Illinois. She is about five feet, three inches in height and is inclined to be stout. She has brown hair. She was her mother's only child, but her father, who was considerably older than her mother, had, by a previous marriage, another daughter several years C's senior. C graduated from college in the same class with No. 3, ranking high in the class and for one year previous to their marriage taught school. Her health was for the most part good, except for an operation for appendicitis in 1912, until some time after the birth of her first child, after which she nursed not only her own baby but also a neighbor's child. Since that time, she has not been in such good health, has been quite nervous and has undergone two operations, the last one for goiter in 1922.

They have had two children, both daughters, and both born in Seattle, Washington. M, the elder, was born October nineteenth, 1913. She was an eight months child. She has had no serious illness except influenza two or three times; the first time she was very ill with double pneumonia. Both she and the younger child have, like their father, undergone tonsilectomy. B was born September second, 1915. For the first three years of her life she was quite sickly, and much difficulty was found in finding food that would agree with her. She still has some stomach trouble, and is rather nervous. She has had influenza three times, which has affected her heart.

In studying their growth curves in comparison with their father's, we note that M was slightly shorter and lighter than her father at first, but at five years her weight line crossed his and at about eight years her height line. Doubtless her better environment accounts for her greater weight and the earlier adolescent growth in height in girls for the crossing of the height lines; for this last year she has gained much more rapidly in both height and weight than before. B's early ill health shows up plainly in her weight curve, which is below her sister's, although she is the taller of the two, until about three and a half years, which is the time improvement took place in her health. The two sisters' height curves parallel each other throughout, B at all times being the taller, as she was at birth. The two sisters' intelligence quotients at five and seven years are almost identical; M's was 122, and B's 123.

Family of No. 5

No. 5, M, born November 27, 1891

For No. 5's family we have very little data. He left college in his freshman year and after a time became a building contractor and settled in a

small town in Iowa. He was married October twentieth, 1914, to A.

A was born January seventeenth, 1896, in Iowa, and has spent practically her whole life in a small town in that state. She has dark brown eyes and hair; is about five feet, five and a half inches in height and is slender. She was the fourth of a family of three boys and three girls and is of German descent. She graduated from high school.

Their son and only child, Junior, was born January thirteenth, 1916. Junior's height and weight measurements have not been regularly kept. He is taller than his father at the same age. At five years, eight months, Junior was forty-three and a half inches tall, at six years forty-five inches, and at seven years, three months, forty-eight inches, while his father at six years, two months, was forty-two and a half inches tall, and at seven years, three months, forty-five and three-eighths inches. Junior's intelligence quotient by the Stanford-Binet scale at two years was 113; at three years seven months, 101; at five years eleven and one-half months, 101; at six years seven months, 104. His vocabulary at two years numbered seventy-eight words and at three years five months approximately 600 words (counted during one week and checked up with dictionary). At seven he is in the second grade at school, but shows much more ability and liking for work with his father's tools or paint brush than for reading. He has red hair and grey eyes. His mother, whose hair is nearly black, has a nephew who also has red hair.

Family of No. 6

No. 6, M, born November 13, 1893

No. 6 easily passed the physical examination for the army in 1917, and, entering as a private, became a second lieutenant in the engineers before the war was over. He was married October eighteenth, 1919, to R and is now teaching in a Michigan high school.

R was born April seventeenth, 1890. She had a twin brother; and there were three other girls and one other boy in the family. She was a capable stenographer before her marriage. She is five feet one and one-half inches tall, weighs about 136 pounds, has blue eyes and light hair.

Their daughter, S, was born May eighth, 1921. Her birth was difficult, instruments being necessary. As her mother had not enough milk for her, she did not gain well at first. Her height and weight curves in comparison with her father's are shown in Figures 12 and 13. It will be seen that starting at near the same point in weight he gained much more rapidly at first, during the period corresponding to that in which S was underfed, than when he was weaned and his long serious illness began. S's weight curve then crossed his, but now it is at about the same point below his that it was at birth. The crossing of her height curve above his seems to corroborate our theory that No. 6 lost his birth rank in height among his brothers, owing in part to his serious illness in early life.

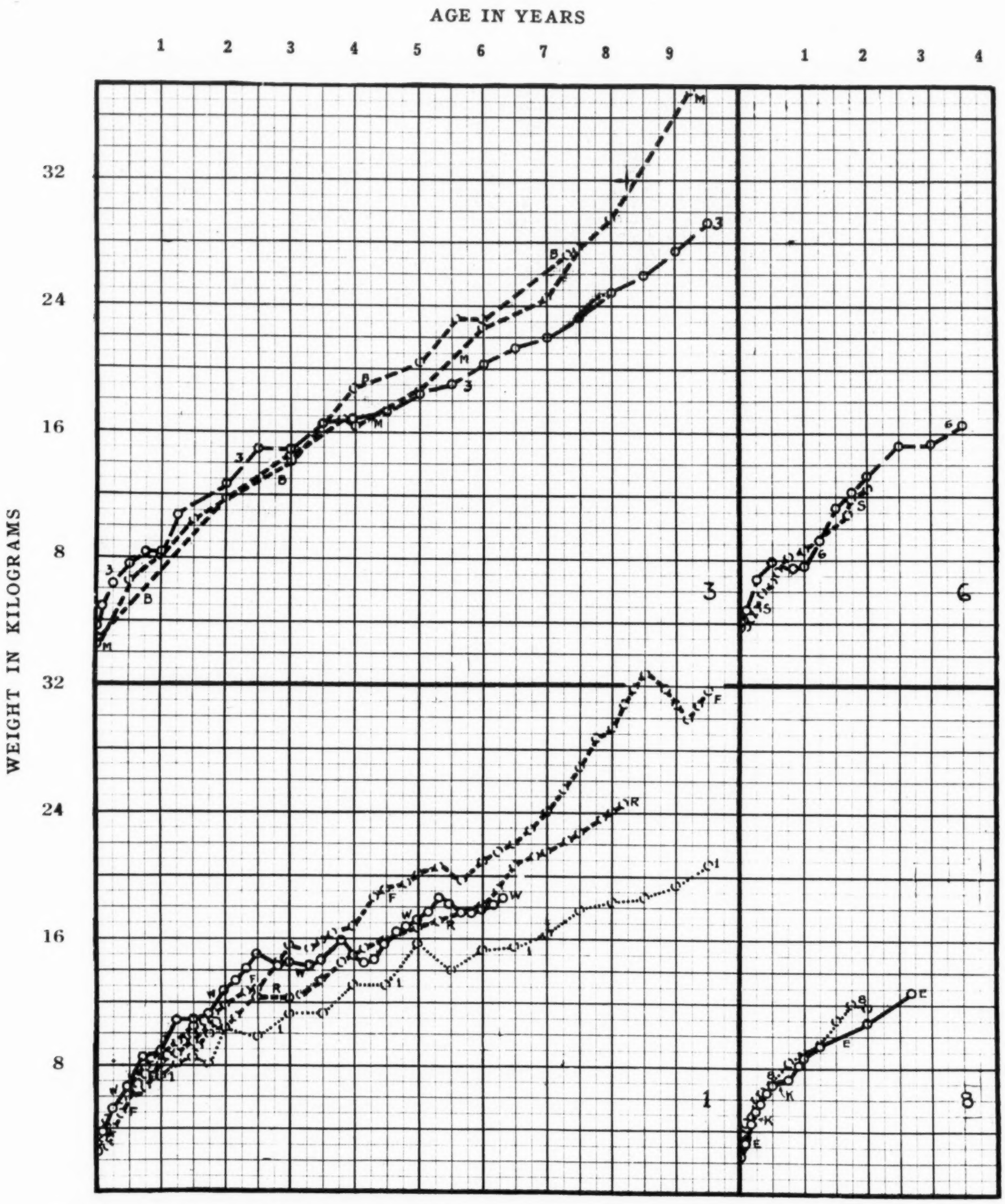
She first walked with support at eight months, her father at nine, and she walked alone at eleven and a half months, he not until sixteen months, the delay being due to his illness. At eighteen months her vocabulary numbered fourteen words and the next month twenty-two words. Her first tooth was cut at seven months twenty-seven days, twenty-five days later than her father's and her twelfth tooth was cut at nineteen months, three months later than his.

S has dark blue eyes and dark hair. At two years, three months, S's intelligence quotient was 111.

Family of No. 8

No. 3, F, born July 26, 1898

No. 8 left school after her sophomore year at college and was married August twenty-seventh, 1919, to C. I., a Canadian draftsman just returned from five years overseas in France. C. I. is five feet eight and a half inches



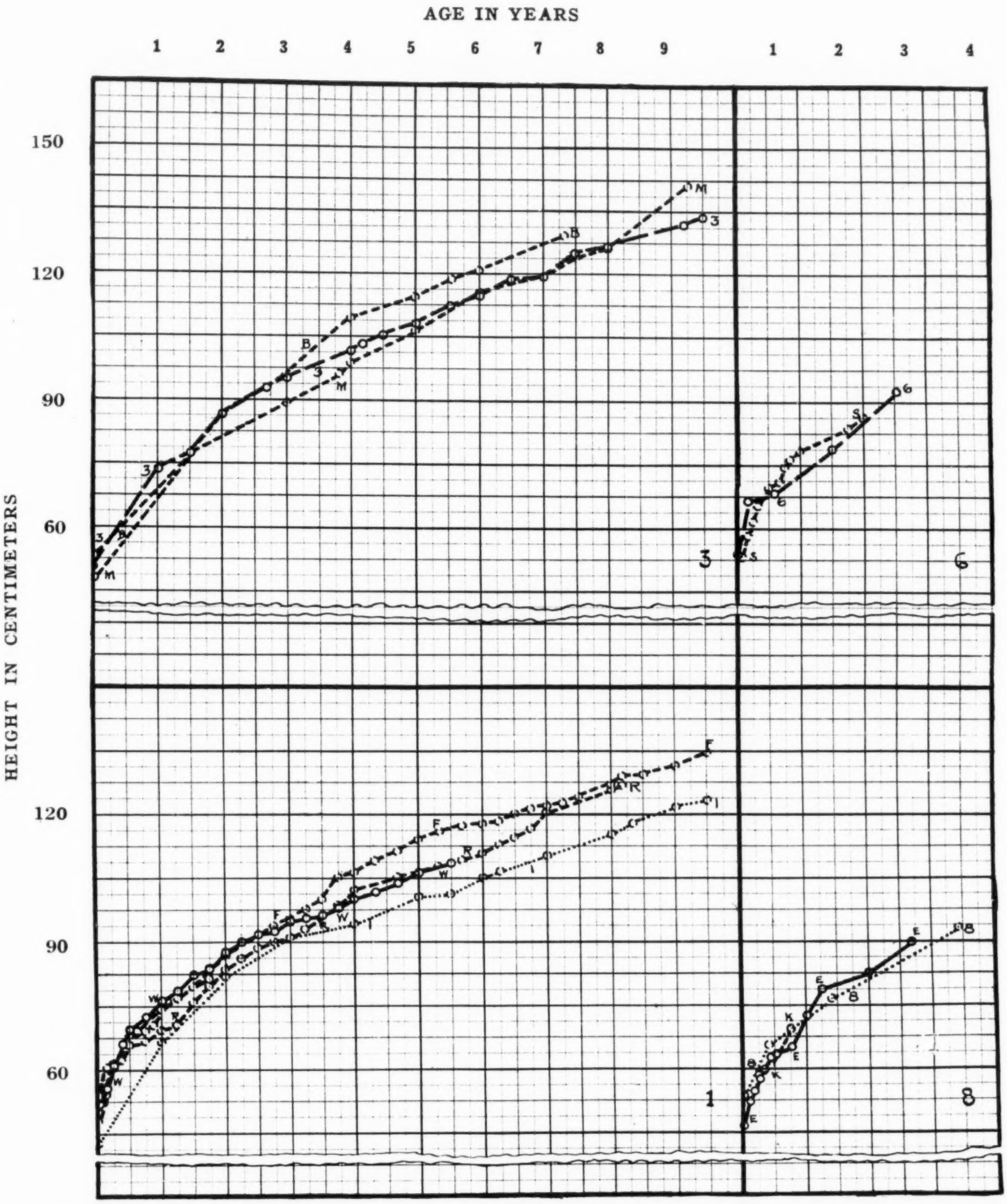
INDIVIDUAL GROWTH CURVES IN WEIGHT IN TWO GENERATIONS

Figure 12

No. 1 has the most irregular curve. The first thirteen years of her life were spent under poor health conditions in China. Her children are also living in China, but under better conditions. Their weight curves are more erratic, however, than those of their cousins who live in the United States. (Male parent, — — — — —; female parent, ...; boys, ————; girls, - - - - -.)

tall, weighs between 135 and 140 pounds. He has grey eyes and dark brown hair. He is of English descent, the eldest in a family of seven boys and one girl, and was born October fifth, 1891.

They have two children, a boy, E, born September fifteenth, 1920, and a girl, K, born August eighth, 1922, both in Iowa. As E was an eight months child, and from eighteen to twenty-two months was ill with influenza, pneu-



INDIVIDUAL GROWTH CURVES IN HEIGHT IN TWO GENERATIONS

Figure 13

The parents, except No. 8, are surpassed by their respective children at corresponding ages. (Male parent, — — — — —; female parent, ...; boys, ————; girls, - - - - -.)

monia, mastoiditis, and later whooping cough, comparisons are not of much value. However, graphs of the babies' height and weight compared with those of their mother are given in Figures 12 and 13. We note a close correspondence in the curves. K, the girl, is just the height and is slightly heavier than her brother, but she was the second child, was born at full term, and has enjoyed good health.

E cut his first tooth late, as did his mother, at thirteen months. He spoke his first word and took his first steps

alone at fifteen months, and at sixteen months walked freely. His illness intervened, and at twenty-three months he had but six teeth and used only sixteen words, but at twenty-seven months his vocabulary had increased to ninety words, with a beginning made at combining words, and at twenty-five months he had twelve teeth. He cut his last tooth a few months after his third birthday. His tonsils were removed at two years, nine months. His intelligence quotient before tonsilectomy was 86; at three years, nine months, it had risen to 93.

E has blue eyes and light hair and resembles his father at that age. K has dark eyes and brown hair and looks more like her mother.

K at nine months had four teeth, all cut within the month, walked with support, and stood alone for a few seconds. Before she was twenty months old she had twelve teeth. She has had much better health than her brother and has developed more rapidly than he.

Comparative Ranking in Height of Children and Grandchildren

The height curves of the third generation children, except No. 8's children, are all above those of their parents. In the case of No. 1's children this is probably due to their tall father. In the case of No. 3 and No. 6, whose consorts are of similar stature, when sex is taken into consideration, the children's greater height may be due in part to a more favorable environment. The shorter stature of No. 8's children may be partly explained by the fact that as the eighth child she was the tallest for her sex, 21 inches at birth; her first child, a boy, was premature; her second child, a girl, was 20½ inches at birth, very slightly less than her own height at birth.

Summary and Conclusions

The findings with regard to the eight children and eleven grandchildren that seem of some significance in the study of hereditary and familial characteristics are:

1. The later born children were heavier than the earlier born children except for No. 8, who was born during her mother's ill health.
2. The later born children were taller than the earlier born children, boys and girls respectively, except for No. 5, the shortest of the boys.
3. At birth the boys were heavier and taller than the girls; they have maintained this superiority.
4. There was a strong tendency for the children to hold until maturity the rank in height that they held at birth. Prolonged serious illness in infancy seemed to affect the adult height of No. 6 and No. 8.
5. May to November were the best months for gain in height of the eight children and they are the best for the eleven grandchildren.
6. The summer months were the poorest for gain in weight for the eight children. One family of five grandchildren shows the best gains during June and July; the conditions under which the children and the various families of the grandchildren live are so different, however, that comparative conclusions can not be drawn with regard to seasonal variations.
7. There was a tendency for children who began dentition early to finish early and those who began late to finish late. The children of two of the sisters who began dentition late have repeated the order of dental development of their mothers.
8. The height curves of the third generation children, except No. 8's children, are all above those of their parents.

Table I. Consecutive Weights of Boys and Girls, with Notes on Influencing Factors from Birth to 22 Months.

	Girls				Boys			
Order of Birth	1	2	4	8	3	5	6	7
Date of Birth	Jan. 23, '86	July 2, '87	June 14, '90	July 2, '98	Nov. 12, '88	Nov. 27, '91	Nov. 3, '93	Feb. 14 '97
Birth Weight	5 lbs. 8 oz.	7 lbs. 2 oz.	8 lbs. 8 oz.	8 lbs. 5 oz.	8 lbs. 0 oz.	8 lbs. 7 oz.	8 lbs. 14 oz.	10 lbs 3 oz
1 Wk.		7-7	8-8	8-0	8-8	8-5	8-6	9-13
2 "		8-0	9-0	8-3	9-0	8-6¼	9-2½	10-5
3 "		8-4		8-11¼	10-0	8-15	9-12	10-14
1 mo.	5-8	4 wks. 8-8	5 wks. 10-0	9-10	11-0	9-10	10-12	11-8
2 "	6-8	10-0	10-12	11-6	12-8	11-10½ chicken pox	13-4	12-2
3 "	8-8	11-0	11-4	13-0 fever, weaned	14-0 measles	12-15	15-0	15-6
4 "	11-8	13-0	12-0	13-8 indigestion	14-8	14-2	16-1½	16-11
5 "	12-4	13-8	13-0	14-4	16-0	15-1	16-14 weaned	17-12
6 "	13-4	14-8	14-0	15-8	16-12 weaned	15-13	17-5	18-5 abcesses
7 "	14-0	14-12 weaned	14-4	16-9 whooping C.	17-0	15-10½ fever	16-13 7½ wks.	18-15 weaned
8 "	15-0 weaned	16-0	16-0	17-8	17-12	14-5 weaned	16-11	19-7 fever
9 "	15-8	16-8	16-8 weaned	18-2	18-8 whooping C.	14-12	diarrhoea	19-14
10 "	16-0	17-0	17-8	18-5½	16-0	16-2	16-11½	21-4
11 "	16-0	17+	18-8	19-6	18-0	16-15	16-6	22-4
12 "	16-0 p	18-8 diarrhoea	18-8	19-7 15½ mos.	18-8	17-12	16-15¼	23-10
13 "	17-0	17-8	19-0 cholera infan.	19-14	21-0	18-11	18-8 malarial scurvy	24-4 fev
14 "	17-2		15-0	21-0	23-4	18-14	17-14 chicken pox	24-
15 "	18	18-4 15¼ mos.	18-0	21-0	23-12	20-5½	20-5 bronchitis	26-. fever
16 "	17-4 17¼ mos.	19-0	19-0	23-0		21-5½	22-0	26-4 indigestion
17 "	18-8	21-12	19-12 18¼ mos.	23-6	25-2	21-11 whooping C.	23-12 fever	25-15
18 "	18-12	21-8	20-12	24-4	18¼ mos.	21-12	24-15 fever	26-8 teething
19 "	17-4	22-12	21-4	24-4	25-8	22-1	26-1	25-2 19¼ mos.
20 "	19-0	measles	22-0	(28)	25-4	22-6 teething, diarrhoea	26-10 21¼ mos.	25-8 diarrhoea
21 "	18-0	22-12	24-0	(28) 29¼		21-15	27-0	25-12

TABLE 2—Data on the Physical Characteristics and Development of the Eight Children and Five Grandchildren (No. 1's Children).

No.	Period of Pregnancy	Sex	Date of Birth	Place of Birth	Color of Hair	Color of Eyes		Eyesight	Age Weaned	Sits Alone	Creeps	Stands	
						in Infancy	Adult					With Support	Alone
1.	275 days	F	1-23-'86	Shangnai	Med. Br.	brown	brown	glasses 18 yrs.	9 mos.	6 mos.	9 mos.	9½ mos.	13 mos
2.	279 "	F	7-2-'87	"	" "	grey	brown	glasses 28 yrs.	7½ mos.	6 "	9½ mos.	9½ "	12 "
3.	280 "	M	11-12-'88	"	" "	blue	grey	glasses 13 yrs.	7½ "	6½ "	6 "	7 "	
4.	280 "	F	6-14-'90	"	dark "	brown	dark-brown	glasses 14 yrs.	10 "	6 "	10 "	10½ "	
5.	280 "	M	11-27-'91	"	" "	blue	grey	glasses 9 yrs.	8½ "	5½ "	10½ "	11½ "	13½ "
6.	280 "	M	11-3-'93	"	light "	blue	grey		5½ "	5 "	never	9 "	11 "
7.	280 "	M	2-15-'97	Ningpo	med. "	blue	grey	excellent	8 "	6 "	8½ mos.	10½ "	12 "
8.	281 "	F	7-26-'98	"	dark "	brown	dark brown	glasses 16 yrs.	3½ "	5½ "	9 "	9 "	11 "
F.	274 "	F	2-7-'13	Suiru, China	brown	blue			artificial feeding		11 "	7 "	12 "
R.	272 "	F	2-10-'15	"	tow	blue			6 mos.		6½ "		12 "
W.	273 "	M	12-28-'16	Iowa City	brown	brown			2 "		7 "	7½ "	12 "
L.	271 "	F	6-23-'21	Mt. Omei, China	light Br.								
C.		F	3-17-'23	Chengtu, China									

No.	Walks		Dentition				First Menstruation	Sitting Height (adult)	Stature Index (adult)	Vocabulary			
	with support	Alone	Cut 1st Tooth	Cut 20th Tooth	1st 6-yr. Molar	Lost 1st Tooth				First Word	Combines Words	Twelve Months	Twenty-one Months
1.	10 mos.	14 mos.	11 m. 12d.	32½ mos.		6y. 7m.	13y 4m.			11 mos.			
2.	11 "	14 "	6½ mos.	29 "	5y 11½ m.	6 " 2"	14y 4m.	34¼ in.	.561	10 "			
3.	8½ "	15½ "	6 m. 5d.	24m. 17d	6y-	6" 8"		36½ "	.522	11½"	18½ mos.		
4.	12½ "	16½ "	8 m. 1d	28m.	6y 6½ m.		14y 4m.	34 "	.533	12 "	21 "		
5.	12 "	14½ "	9 " 5"	28m.				36½ "	.557	10 "	20 "		
6.	11½ "	16½ "	7 " 2"	24m.		6y 2m.		35 "	.513	8½"	17 "		
7.	10½ "	13½ "	8 " 4"	28m. 6d				38 "	.539	10½"	16 "		
8.	10½ "	12½ "	13 " 1"	34m.			13y 11m.	33½ "	.549	8½"	10½ "		
F.	8 "	14½ "	7 " 14"	32m. 9d.	6y. 2 m.	6y 2d				9 "	18 "	4 Eng.	45 Eng-16C
R.	8½ "	14 "	10 " 7"	35m. 8d.	6y. 10m	6y. 6m.				8 "	16 "	4 Eng.	124 Eng.
W.	8 "	14½ "	10 " 15"	34m.						8 "	16 "	7 Eng.	41 Eng-61 C
L.		13 "	10½"								14 "	9 Eng. 1 C.	(18 mos.) 37 Eng-25 C
C.											(Eng. = English words) (C = Chinese words)		

BROKEN SEEDS IN MAIZE

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BROKEN maize seeds occur at the time the seeds are hardening on ear. The character appears principally on flint or intermediate flint-pop corn varieties cultivated in Italy, and is the main cause of serious deterioration of the crop during the winter keeping. It first becomes manifest as a sudden cleft of the pericarp, which causes a more or less deep alteration of the underlying materials, chiefly of the aleurone layer and of the vitreous and mealy endosperm. This split may be of a great variety of shapes, but is always uniform both on all the seeds of the same ear and on ears of the same plant.

The phenomenon occurs in greater or less degree every year, and fluctuations in the expression of the character are due principally to seasonal variations of the weather at time of ripening, but also, undoubtedly, to the variety. In observing this injury, a number of important gradations of the extent of the split can be found, both as regards the *percentage* of damaged seeds in the ear and even, and above all, the *gravity* of the injury in the seeds. There are indeed ears in which it is possible to count on the fingers of one hand the broken seeds, while in other ears nearly all the seeds are burst. (See Figure 14.)

In regard to the extent of the injury, the first step (Figure 14) is a simple crack of the pericarp, after which occurs the progressive spoiling of the underlying layers (Figure 14). In extreme cases, especially in certain years or progenies, when the moulds penetrate, the seeds become rotten and their spoiled materials adhere to the others, along with the decayed remains of the silks and the inner husks.

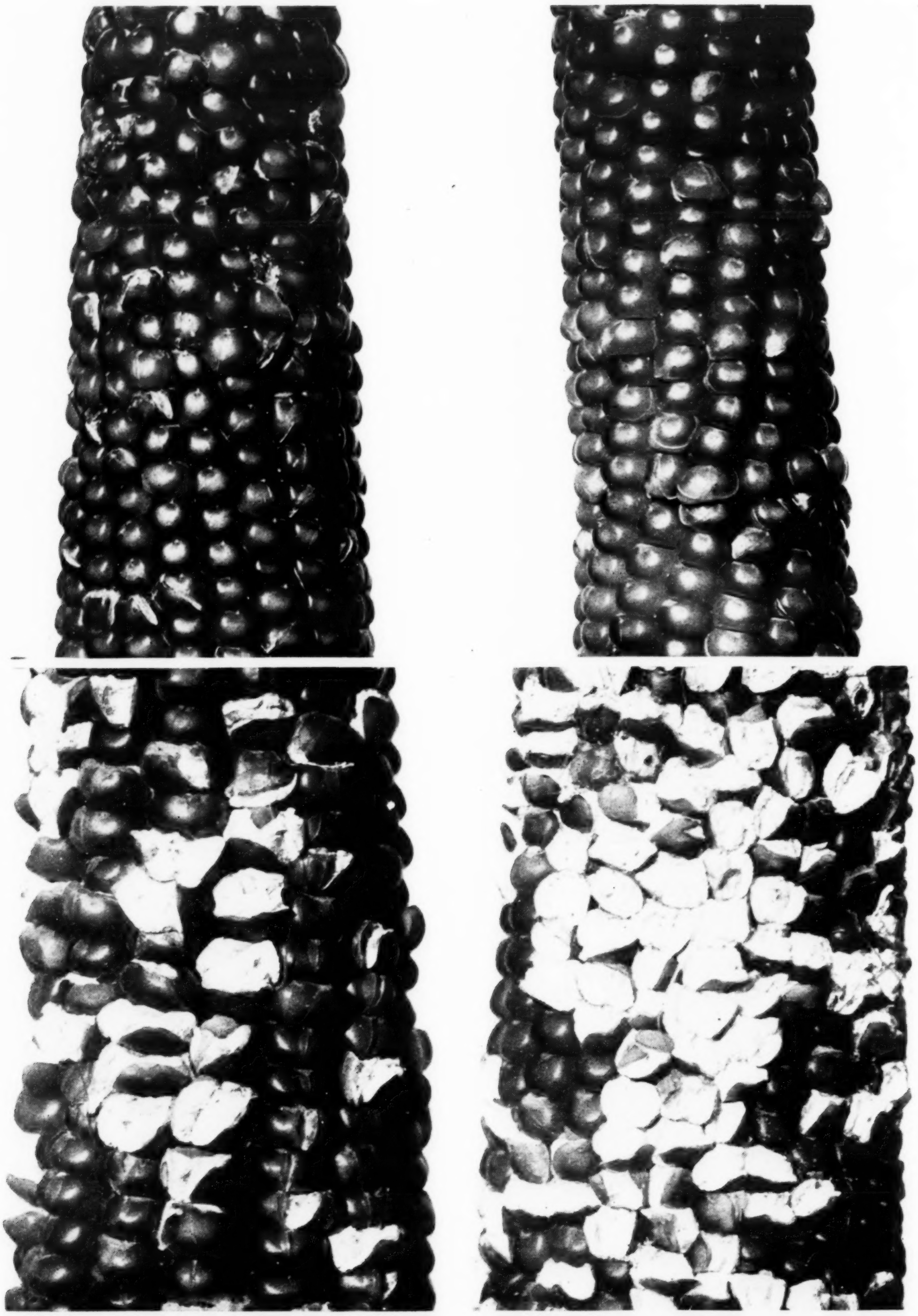
Sometimes the burst seeds occur on the same ear with the well-known "defective" seeds, for broken seeds are found in varieties having mealy endosperm (Figure 15). These defective seeds are also found on ears of sound strains related to greatly injured ones.

The appearance of broken seeds in the common corn crop does not generally cause great harm, but there are some cases in which the percentages, both of ears with burst seeds and of the number of burst seeds on the ear, are so high as to cause considerable damage. These cases occur under abnormal weather conditions and are confined to certain varieties.

Inheritance of Broken Seeds

However, at the *Italian Corn-breeding Experiment Station,* working for the purification and separation of a number of strains by selection in self-fertilized lines in several varieties, it seems that we have found this phenomenon to be of a clearly heritable nature. In certain self-fertilized strains there is a precise separation of types which appear in the first or in the second generations (Figure 15). Probably there will be some new cases of appearance of broken seeds in other strains, sound at present, in successive self-fertilized generations and we will have the confirmation of it in the next years.

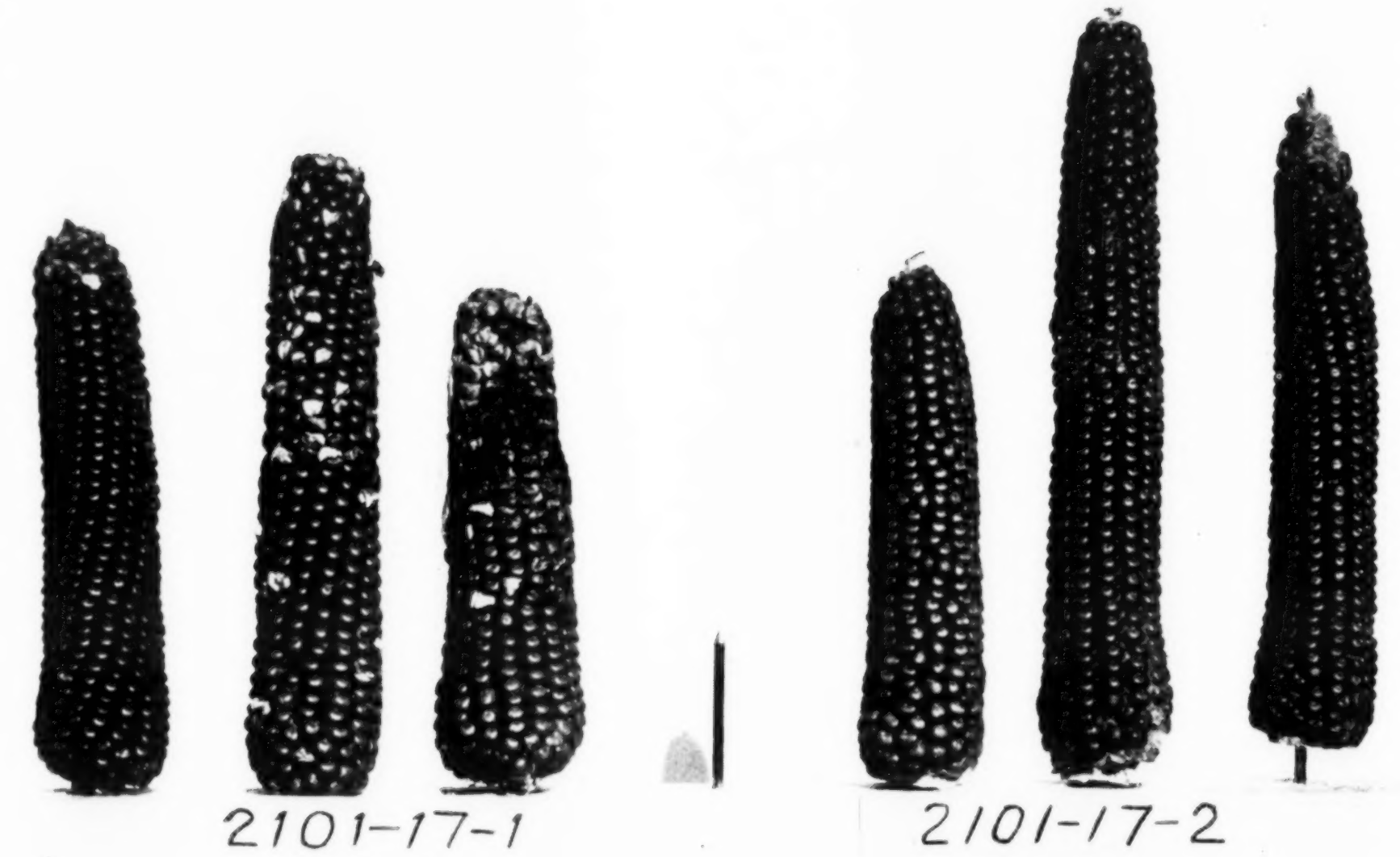
It is proper at least to say that not always and in every case the separation is as clear and precise as is seen in the photographs reproduced here. But, of course, we must consider that, at only the second generation from self-fertilized ears, the heterozygosis is still too great in these strains, derived from a complex hybrid condition, to permit a complete segregation. For that reason we have not yet reported any nu-



FORMATION OF BROKEN SEEDS

Figure 14

The split first appears as a slight crack in the pericarp, which gradually extends to the underlying layers. Moisture enters through the crack and is absorbed by the endosperm, which swells and completes the rupture of the pericarp. In extreme cases the bursting of the seed is so complete that it resembles a grain of popcorn.



INHERITANCE OF BROKEN SEEDS

Figure 15

(Above.) Representative ears from two first generation plants from a single ear (No. 2101-17) of the "Nostrano dell'Isola" variety. The progeny of the first self-fertilized ear (No. 1) is badly damaged by rupture of the seeds, while in the second progeny the grains are all normal. (Below.) Representative ears from three strains in the second inbred generation from ear 2101-17. The normal strain continues to be free from broken seeds (2101-17-2-3). The broken seeded strain produced progenies with broken seeds (2101-17-1-3) and progenies which have only normal grains (2101-17-1-2). Note that in the broken-seeded progeny in the second generation all seeds are defective, even though not all are broken.

merical ratios on the transmission of this character. But we think to have sufficient observations and evidence to affirm that the character "broken seeds" in maize, as above described and illustrated, is clearly of a heritable nature.

NOTE: "Broken seeds" have also been found on cobs of maize excavated from prehistoric ruins in the Southwestern United States. The similarity between these and the modern form is noted by G. N. Collins in an article on the "Agricultural History of Maize," in *Ann. Report of the Agricultural Historical Society*, Vol. 1, p. 417. Washington, 1919.—*Editor.*

A HANDBOOK OF HUMAN HEREDITY*

A Review

AMONG recent works on human heredity, Professor Gates' new book deserves a prominent place in the libraries of those who desire to keep in touch with the latest advances in this field. The twenty-page bibliography takes the reader back to the original sources and makes available much of our fund of knowledge of heredity in man. Perhaps it is noteworthy that of the 347 titles included in the bibliography twice as many are from the JOURNAL OF HEREDITY as from any other publication. It may be a matter of gratification to members of the American Genetic Association that so large a proportion of our knowledge of human heredity has been published in their Journal.

The first twenty-six pages are devoted to a short introductory chapter and to a discussion of the "General Aspects of Heredity," in which such matters as Mendelian inheritance, chromosome behavior, and the like are briefly dealt with. The second section of 117 pages is devoted to the "Inheritance of Physical Characteristics in Man," while sections four and five discuss "Inheritance of Mental Traits" and "Limits of Heredity," the latter being chiefly devoted to twins, identical and fraternal. It is understood that a Russian edition is to appear shortly.

It is a book to be recommended to any intelligent person who thinks that he "don't believe in heredity," or who wishes to have a general idea of the extent of knowledge on the subject. Hundreds of cases of definite inheritance are collected, showing the transmission of many physical and mental defects, often extending for several generations, and some that trace back for centuries. Some of the defects are trivial, but others condemn their victims to suffer all their lives. That such entailment of misery should go on in so many families through many generations shows more conclusively than any other argument the need of such facts being known, not only as scientific data but as an element of our rapidly awakening social consciousness. What other responsibilities should be considered more binding than those to our own children?

The discussion is not limited, of course, to inheritance in man. Our knowledge of human heredity is still so inadequate that we must rely for enlightenment and suggestions on the far more complete studies in other organisms. Neither is the book a dry listing of dominant and recessive characters. In the history of some of the more striking cases are found elements of romance. The recent dis-

*GATES, R. RUGGLES. Genetics and Eugenics. Pp. xiii + 288. Price $3.00. The Macmillan Company, London and New York. 1924.

It is to be regretted that a more original title could not have been devised. To American readers and libraries especially the existence of two books with the same name is likely to cause no little confusion.

covery of "white Indians" acquires a new significance when we are reminded that Wafer, in his description of Darien in 1681, gives a circumstantial account of "White Indians," estimates their numbers at "two or three hundred," and states that they were not offspring of Europeans and were "not a distinct race by themselves, but now and then one is bred of a copper-colour'd Father and Mother." The existence of such a large number of albinotics in one district is the more noteworthy when we consider that while "Albinism is known in most races and probably occurs in all," its general frequency is estimated at 1 in 5,000 to 1 in 30,000.

The story of the fused finger bones of the first Earl of Shrewsbury carries us back to Shakespeare and Joan of Arc:

> Drinkwater (1917) has described yet another digital abnormality, which is remarkable for the number of generations for which it is known to have been handed down in one family. The peculiarity is as follows, as found in the hands of a gentleman, A. T., of the present generation: In the middle finger the joint between the middle and basal phalanges is only very slightly movable, the articular surfaces of the bones being enlarged, while in the ring and little fingers there is no joint between the proximal and middle phalanges, these two being completely fused into one. All the fingers are movable at the distal joint, and both hands are alike. All the toes, except the hallux, are affected exactly like the ring and little fingers. This man's father and *his* mother are known to have had precisely the same abnormality. His father married twice, and one of the half-brothers shows it. The most interesting feature of this case is that A. T. is a direct descendant in the male line from John Talbot, the first Earl of Shrewsbury, who figures in Shakespeare's *Henry VI.*, and was killed in battle near Bordeaux in 1453. Tradition has it that his thigh bone was broken while on horseback, and that when he fell from his horse he was killed by the blow of a battleaxe on the head. His body was buried in a tomb inside the church at Whitchurch, which was surmounted by a stone effigy. In 1874 the tomb was opened and repaired by one of his descendants. The finger bones, when examined, showed the same ankylosis that exists in his modern descendant. On the stone effigy the fingers, which were somewhat damaged, also showed precisely the same thickening of the middle joint as described in his descendant. Clearly, then, this defect has been handed down for more than 500 years as a Mendelian dominant, and the genealogy of the family shows that it must have been inherited through fourteen generations. This, I believe, is the longest period on record for the tracing of an anatomical abnormality in man, though the Hapsburg jaw extends back equally far.*

The last section, on "Social and World Aspects of Eugenics," includes such chapters as the Basis of Racial Temperamental Differences, Results of Crossing Between Races, and Quantity and Quality of Population. The question of the number of species of the human race is considered at length, and several divergent views are presented. Our author calls attention to the difficulty of deciding the separation of species on superficial appearance, on the fertility or infertility of crosses, or on the ultimate effects of racial interbreeding. Some species that look alike do not cross, while others that seem very different are entirely fertile in crosses. It is pointed out that "very few serious studies of racial crossing have been made, and probably no field of anthropology could be more profitably explored at the present time."

A study of the Pitcairn and Norfolk Islanders is suggested as a good place to begin. The history of these people goes back to the mutiny of the *Bounty*, which put an end to "Breadfruit Bligh's" first attempt to introduce that valuable tree into the West Indies. After setting Captain Bligh and the loyal members of the crew adrift in an open boat, the ten mutineers took on board twelve Polynesian women and six men and set sail for Pitcairn

*Photographs of an abnormality evidently very similar to this were published in this Journal for October, 1924.

Island. "In 1856 the resulting population of 200 overflowed to Norfolk Island, and the descendants of this crossed race now number about one thousand. They should form excellent material for the anthropometric study of a population descended from original crosses between Polynesians and English."

The effects of adverse selection in gradually eliminating the more capable elements of the civilized nations are recognized, but no solution is proposed for this fundamental problem of eugenics. The concluding chapter on "Population and Quality" is very short, and contains the following significant statement:

> The problems envisaged in the last few paragraphs have been so much written about in recent years that we do not propose to discuss them further here. They remain at the heart of all questions of racial improvement through eugenic ideals. The problem of formulating laws which would foster an increase in the more efficient and desirable members in each stratum of society would seem almost to surpass the wit of man, and so far as we know, it has not yet been successfully accomplished in any community. The task appears all the more appalling when it is remembered how frequently Parliamentary laws have an economic effect quite different from that anticipated or intended.

Stature in Man

BODY BUILD: ITS DEVELOPMENT AND INHERITANCE, by C. B. DAVENPORT, Director of the Department of Genetics, Carnegie Institution of Washington. Eugenics Record Office Bulletin No. 24, pp. 42. Cold Spring Harbor, L. I., N. Y., February, 1925.

This bulletin is an abstract of Dr. Davenport's study of the same subject, which was issued in 1917 as Pub. No. 329 of the Carnegie Institution. It has been prepared to make the results of that study more widely available to those interested in heredity. The author presents evidence of segregation in the inheritance of body build, discusses some detailed pedigrees, and concludes that in many cases, at least, three independent factors seem to be at work, all of them influencing height in a general way by means of separate endocrine glands (hypothetically, the pituitary and thyroid glands and some other gland, perhaps the gonads). Little is said in this abstract of the supposed factors influencing separately the length of various parts of the body—factors postulated in the earlier study, whose reality was doubted in criticisms of W. E. Castle and others. While the data are not extensive enough to settle the genetic details, Dr. Davenport's work leaves no room for doubt that Mendelian factors are concerned in the inheritance of body build in man.

P. P.

HEREDITARY DEAF-MUTISM

A Study of the Mendelian Factors in the Inheritance of Deaf-Mutism*

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DEAFNESS, according to Dr. Gustav Alexander[1], may be due to several causes; hereditary taint of impaired hearing; anomalies of the face, extremities, or trunk; nervous taint; hereditary syphilis; or deafness acquired through accident or sickness. Syphilis, a disease acquired by the parents and at certain stages curable, causes various pathological conditions when transmitted to the offspring, such as blindness, deafness, etc. If proved to be present in the parents, this might explain such abnormal ratios as one deaf to ten normal offspring in a famliy with no deaf relatives.

Deafness due to hereditary causes is divided into two types, deaf-mutism and otosclerosis. Of these, otosclerosis usually comes on later in life, and is due to a calcareous deposit in the labyrinth, sooner or later affecting both windows and eventually causing total loss of hearing. While this condition does not usually show up in impaired hearing until puberty or later, it may be present at birth; and if it affects the windows at that time, would result in partial or total loss of hearing. These cases are, however, rare and would appear only in families showing otosclerosis. As this type of deafness is dominant, congenital deafness caused by it would occur only in children who had at least one parent showing otosclerosis.

Acquired deafness can be traced to inflammation of the labyrinth, affecting the entire labyrinth, static and acoustic. In these cases there is absence of excitability of the static labyrinth; while in congenital deafness, there is preserved function of the static labyrinth in a large per cent of the cases.

True (hereditary) deaf-mutism, which we are considering in this article, is always congenital, and is due to failure of proper embroyonic development of the cochlear nerve, spiral ganglion and Corti's organ; or to atrophy of these parts owing to congenitally defective or arrested development in the area of the capsule of the labyrinth of the middle ear. In some cases remnants of hearing may be observed.

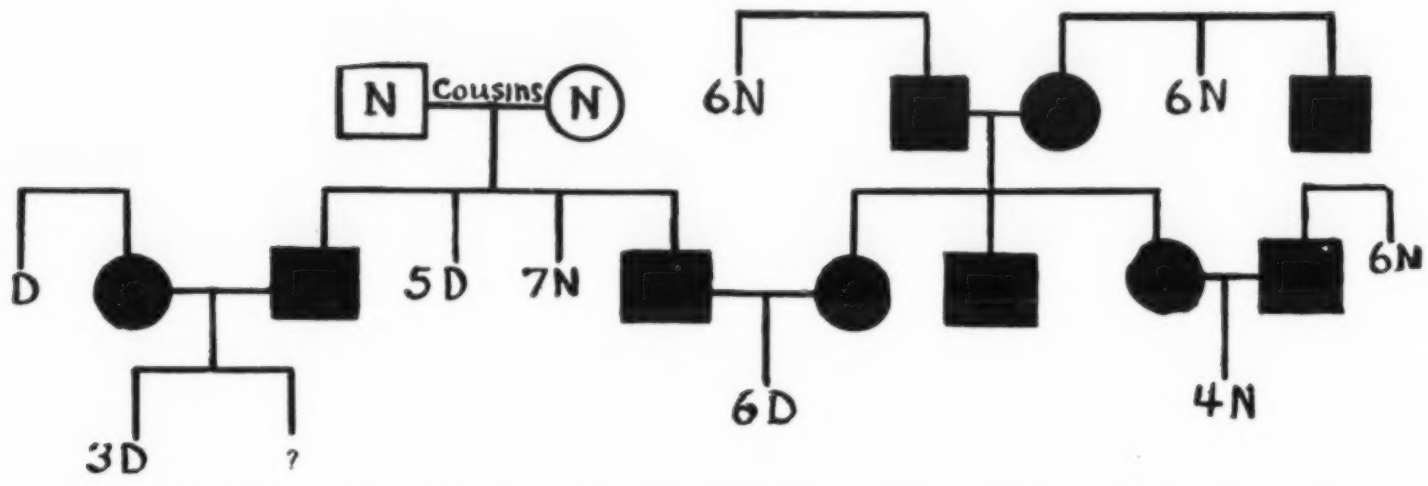
This study is an attempt to explain the inheritance of Deaf-mutism on a Mendelian basis; and was undertaken under the direction of Dr. W. M. Barrows, of Ohio State University. References on the pathological conditions of the ear were obtained from Dr. H G. Beaty, Columbus, Ohio.

For this purpose, data were obtained of marriages of deaf to deaf, deaf to normal, and normal to normal producing deaf children. Data for the marriages of deaf to deaf, and deaf to normal was taken from Dr. Fay's "Marriages of the Deaf,"[2] in which he published the records of 4,471 marriages of the deaf with the number of offspring of each. A record of all of the deaf relatives of each partner in the marriage was given, and the record

*This paper was presented as a partial fulfillment of the requirements for the degree of Master of Science, Ohio State University, 1923.

[1]ALEXANDER, GUSTAV. Translated by Bedell, A. J. Diseases of the Ear in Childhood and Infancy. Pp. 234-246.

[2]FAY, EDWARD ALLEN. 1898. Marriages of the Deaf in America. The Volta Bureau, Washington, D. C.



MARRIAGE OF DEAF PRODUCING NORMAL OFFSPRING

Figure 16

The chart shows a deaf by deaf marriage in which all the children were normal, and two marriages which resulted in all the children being deaf. Two normal cousins had equal numbers of deaf and of normal children. These results can be accounted for if we assume that deafness is conditioned by two (or more) recessive Mendelian factors.

Circles indicate females, squares males; N=normal; black symbols or D=deaf; no symbol=sex unknown; ?=not known whether deaf or normal.

number, if any of these relatives were included in the record of marriages. By tracing out these relationships, it was sometimes possible to work out quite complete family pedigree charts.

As the records of Dr. Fay did not include any marriages of normal by normal producing deaf offspring, these records were obtained from the records of the Ohio State School for the Deaf, through Dr. J. W. Jones, superintendent.

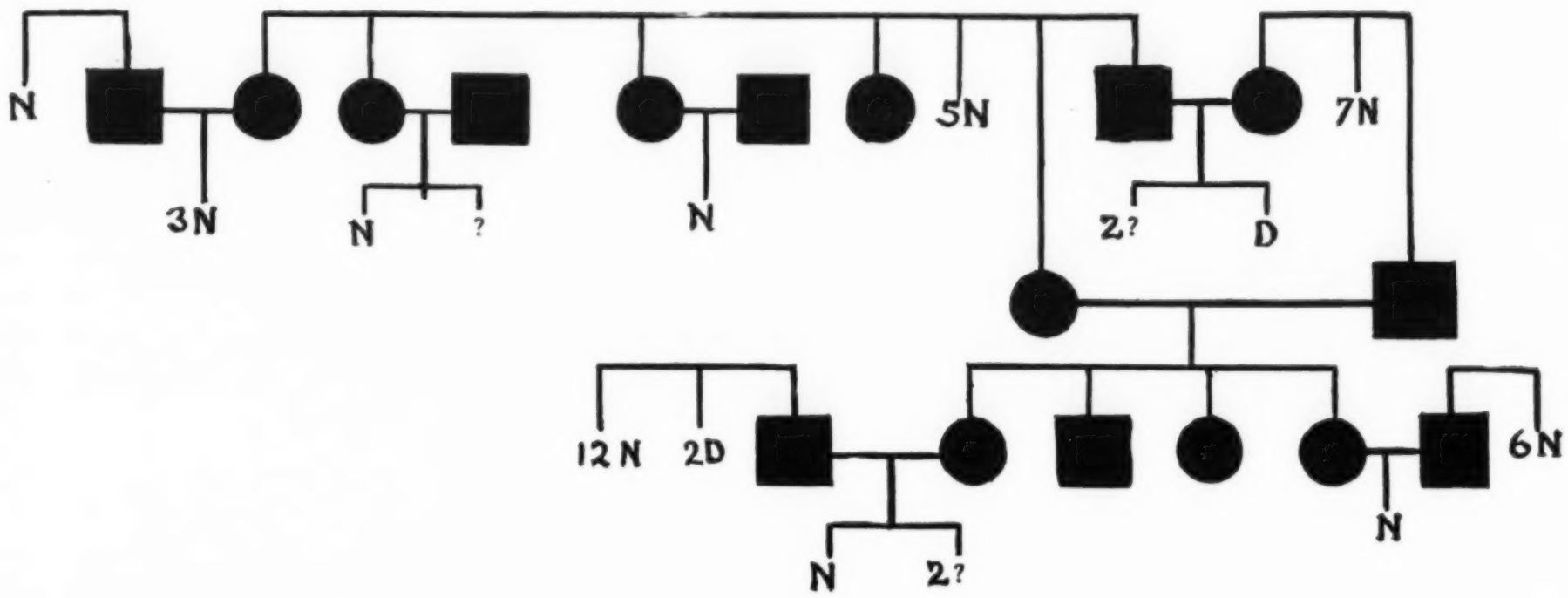
In the deaf by deaf, and normal by normal marriages, only families of five or more children were considered, while in the deaf by normal families, owing to the fewer records available, families of three or more were used.

Considering the data first from the point of view of a single dominant factor: in this case deaf by deaf marriages would produce either all deaf offspring or deaf and normal in the ratio of three deaf to one normal. No cases of all normal offspring would be possible, while there were actually found 150 such cases. In marriages of deaf by normal the offspring would either be all deaf or give a ratio of one deaf to one normal, depending on whether the deaf parent was heterozygous or homozygous for the deaf factor. Normal parents could never produce deaf offspring, while thirty-seven such cases are shown in the data.

If deafness were due to a single recessive factor, deaf by deaf could never produce anything but deaf offspring, while we actually have from this cross families of all normal and of deaf and normal. In crosses of deaf by normal the offspring would be all normal unless the normal parent carried the factor for deafness, in which case a ratio of one deaf to one normal would be produced. While in normal by normal crosses, if both parents carried the factor for deafness, there would be produced a ratio of one deaf to three normal; otherwise the offspring would all be normal.

Nor is deafness a sex-linked character. All marriages of deaf by normal were separated out on the basis of whether the father or the mother was deaf (Tables III. and IV.). Practically the same ratios were obtained in both cases.

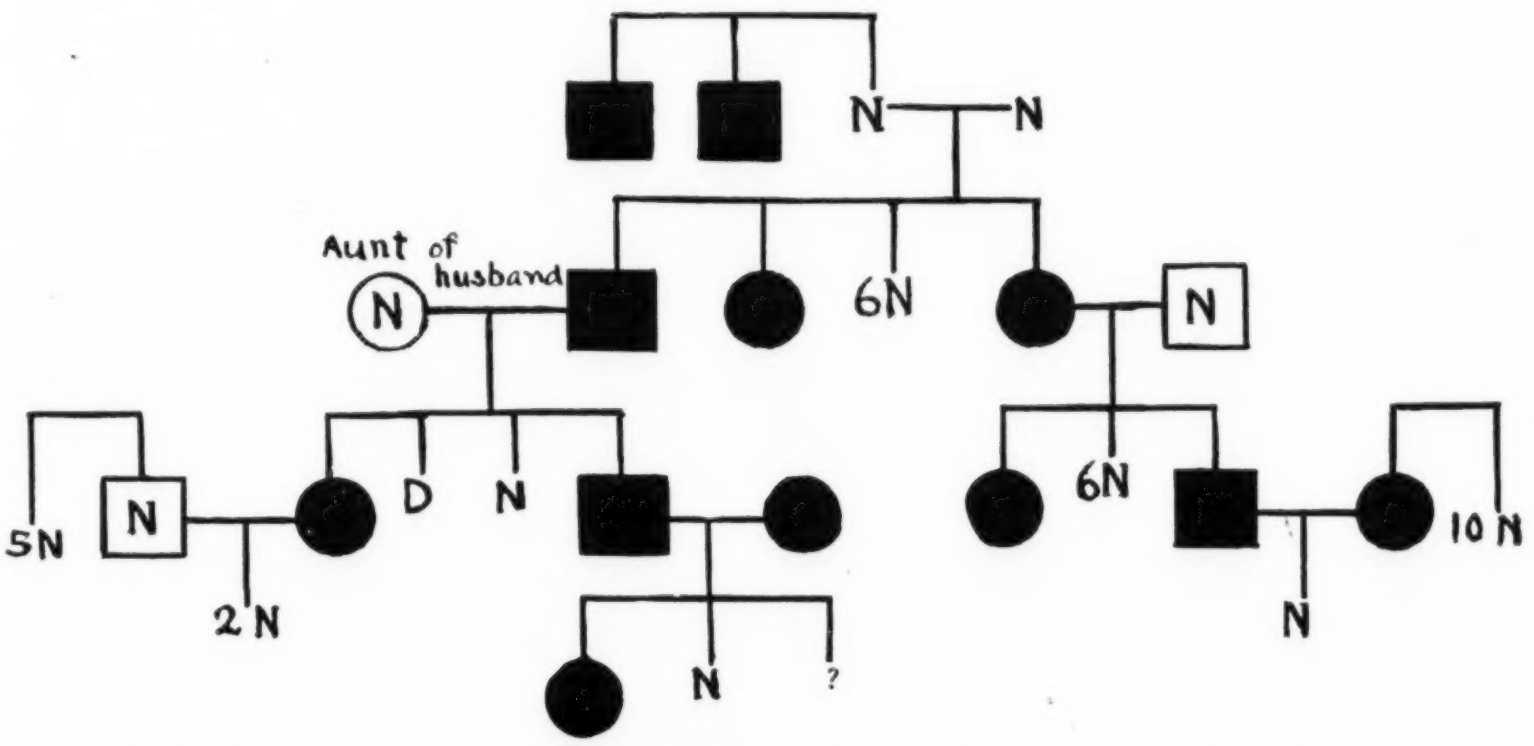
If deafness were due to two dominant factors, deaf by deaf crosses would produce no families of all normal offspring; while 150 such cases were actually found. Crosses of deaf by normal would produce no families of all normal offspring. Actually 165 cases of all normal offspring were found. Crosses of normal by normal might, in one case, produce families of all deaf, but no such case was actually found.



DOUBLE MARRIAGE PRODUCING DEAF OFFSPRING IN BOTH CASES

Figure 17

For explanation of symbols see Figure 16.



INHERITANCE OF DEAFNESS FOR FOUR GENERATIONS

Figure 18

However, if deafness were due to two recessive factors, or rather to the absence of two dominant factors for normal hearing, represented by the symbols BB EE, then if both these factors were present, either singly or doubly, a normal individual would result; but if one or both were absent, a deaf person is produced.

With two recessive factors, as shown in Table I., nine types of individuals with regard to deafness, are possible—BB EE, BB Ee, Bb EE, Bb Ee, bb eE, BB ee, Bb ee, bb ee and bb EE. The first four classes, containing both B and E, would be normal, while the last five classes, lacking either B or E, would be deaf. Table I. gives the possible combinations of these nine types, with the resulting ratios of deaf to normal that would be produced. If Class 1 is crossed with Classes 1, 2, 3 and 4, which are all normal, all normal offspring will result, as also will be the case in a cross between Class 2 and 3. As these are normal by normal crosses, producing all normal offspring, they are disregarded in this paper. In the remaining normal by normal crosses (Classes 1, 2, 3 and 4 with Classes 2, 3 and 4), there are found the possible ratios of one deaf to three normal, or in the cross of Class 4 to Class 4, a ratio of seven deaf to nine normal.

In crosses of normal (Classes 1, 2, 3, 4) by deaf (Classes 5, 6, 7, 8, 9) are found the possible ratios of: All normal, one deaf to one normal, five deaf to three normal, three deaf to one normal, or one deaf to three normal. No families of all deaf offspring are possible.

In crosses of deaf (Classes 5, 6, 7, 8, 9) to deaf are found the possible ratios of all deaf, all normal, one deaf to one normal, and three deaf to one normal.

Under this assumption of two recessive factors, *in the normal by normal crosses, no families of all deaf offspring are possible; nor are they possible in families of deaf by normal crosses.* Nor were families of all deaf found in these crosses. In the deaf by deaf crosses, families of all deaf, deaf and normal, and all normal should be found. Referring to Table II., 150 cases of all normal offspring, 34 cases of mixed offspring, and 11 cases of all deaf offspring were found.

In the normal by normal crosses (Table V.), from which have been eliminated all crosses producing all normal families, 37 cases of mixed offspring are shown. With the exception of two families of three offspring each, which are too small to be conclusive evidence one way or the other, no cases of all deaf offspring were found.

In the deaf by normal (Table V.) there are found 165 cases of all normal offspring, 40 cases of mixed offspring, and no cases of all deaf offspring.

A number of irregular ratios were found. These were all cases of one deaf to several normal offspring. Some of these ratios might be explained by being in reality smaller ratios. Take, for instance, a one deaf to four normal ratio in the deaf by deaf cross. The chances are that this ratio could be produced once in about seven times (5/32), when a 1:1 ratio was expected. This would be the same as having a family of four boys and one girl (a 1:1 ratio being expected here), which often happens.

Some of these irregular ratios might be due to other types of deafness, such as otosclerosis, which sometimes shows up at birth, various types of abnormalities of the head, monstrosities, disease, a possible selective death rate, or the possibility that sperm or eggs lacking the factors for normal ear development are less viable than the others. Dr. Fay[2] says that marriages of deaf to deaf, and deaf to normal with deaf relatives, are less productive generally than normal by normal marriages. Dr. Jones, Superintendent of the Ohio State School for the Deaf, explains much of the deafness as due to consanguinous marriages, in many of which one of the principals was illigitimate, unknown to himself. In such cases deaf relatives, if any, would not all be reported.

Conclusions

Under the Mendelian type of inheritance, it has been shown that deaf-mutism cannot be due to either a single dominant or single recessive factor, nor can it be sex-linked. When considered on a two-factor basis, it is seen that it cannot be due to two dominant factors. But when considered on the basis of two recessive factors, with the exception of a few irregular ratios, all of the data fits this theory. No families of all deaf were found where they were not expected. Families of all normal were found in the deaf by deaf crosses, as expected.

I am offering this two-recessive factors hypothesis as being in harmony with the observed facts, but feel that the problem still needs considerable study.

TABLE I—Showing the possible results, on the basis of the theory presented in this paper of crosses between individuals of the nine classes representing grades of hybrids between normal and deaf persons; and the theoretical ratios of deaf to normal offspring they would produce. B and E represent two factors for normal ear. b and e represent the absence of these two factors. D—Deaf. N—Normal.

			NORMAL				DEAF				
			Class 1 BE BE	Class 2 Be BE	Class 3 Be bE	Class 4 BE be	Class 5 bE bE	Class 6 bE be	Class 7 Be Be	Class 8 Be be	Class 9 be be
		Gametes	BE BE	BE Be	bE BE	BEbE Bebe	bE bE	bE be	Be Be	Be be	be be
NORMAL	Class 1 BB EE	BE BE	All N	All N	All N	All N	All N	All N	All N	All N	All N
	Class 2 BB Ee	BE Be		1 D 3 N	All N	1 D 3 N	All N	1 D 3 N	1 D 1 N	1 D 1 N	1 D 1 N
	Class 3 Bb EE	BE bE			1 D 3 N	1 D 3 N	1 D 1 N	1 D 1 N	All N	1 D 3 N	1 D 1 N
	Class 4 Bb Ee	BEBe bebE				7 D 9 N	1 D 1 N	5 D 3 N	1 D 1 N	5 D 3 N	3 D 1 N
DEAF	Class 5 bb EE	bE bE					All D	All D	All N	1 D 1 N	All D
	Class 6 bb Ee	bE be						All D	1 D 1 N	3 D 1 N	All D
	Class 7 BB ee	Be Be							All D	All D	All D
	Class 8 Bb ee	Be be								All D	All D
	Class 9 bb ee	be be									All D

TABLE II—Deaf × Deaf

	Number Families	*Offspring*	
		N.	*D.*
All Normal	150	923	0
Mixed	34	131	75
All Deaf	11	0	67

TABLE III—Deaf × Normal (Father Deaf).

	Number Families	*Offspring*	
		N.	*D.*
All Normal	94	427	0
Mixed	24	84	59
All Deaf	0	0	0

TABLE IV—Deaf × Normal (Mother Deaf)

	Number Families	*Offspring*	
		N.	*D.*
All Normal	71	298	0
Mixed	16	52	32
All Deaf	0	0	0

TABLE V—Deaf × Normal (Combining Tables III and IV).

	Number Families	*Offspring*	
		N.	*D.*
All Normal	165	625	0
Mixed	40	108	80
All Deaf	0	0	0

TABLE VI—Normal × Normal.

	Number Families	*Offspring*	
		N.	*D.*
All Normal	Not Considered		
Mixed	37	202	59
All Deaf	0	0	0

2,075,000 Leave Farms, 1,396,000 Quit City in Year

Two million and seventy-five thousand persons left their homes on farms to live in the cities during 1924, while 1,396,000 city dwellers migrated to the soil in that period, according to the Department of Agriculture, which announced recently that the farm population of the United States decreased approximately 182,000 last year. The estimated farm population at the beginning of the present year was 31,316,000 on January 1, 1924. These figures include not only the agricultural workers, but all men, women and children living on the farms on that date.

Births among the farm population during 1924 are estimated at 736,000 and deaths at 266,000, leaving a natural increase of 497,000, which reduced the loss due to the cityward movement to 182,000, or .6 per cent.

Two geographic divisions, the New England and South Atlantic States, showed a net increase in farm population for the year 1924 of .9 per cent and .2 per cent, respectively. All other divisions showed decreases, the Mountain States leading, with a loss of 2.8 per cent.